

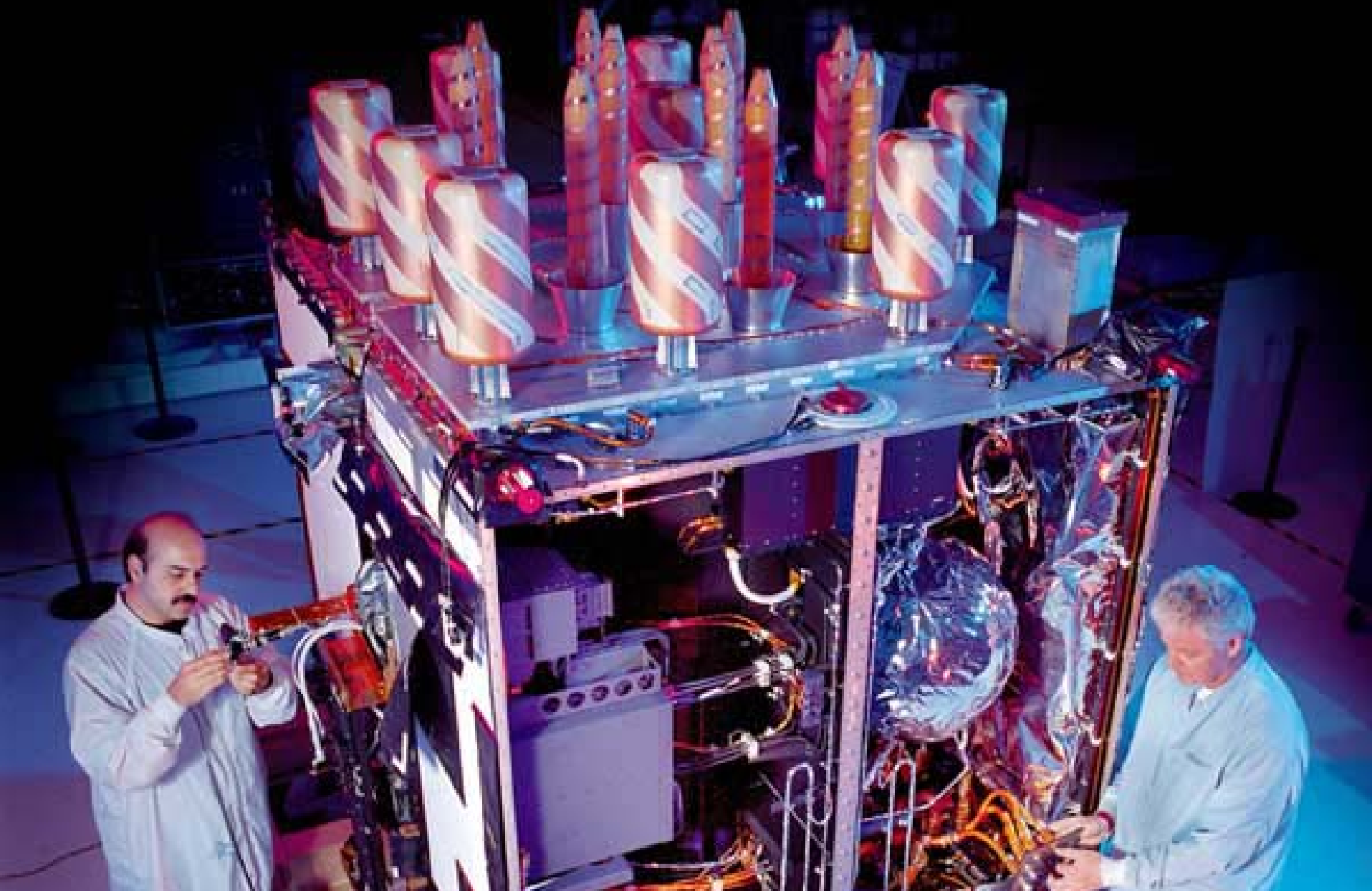
# GPS for Disaster Operations



# Objectives

- Explain FEMA's use of coordinates.
- Explain basic GPS theory as applied to actual field use.
- List common problems and their prevention.
- Demonstrate the ability to configure the unit, obtain, record, and verify coordinates in the field.

# Introduction



# Course Content

- Section 1 Introduction
- Section 2 Mapping and GPS Theory
- Section 3 Unit Features
- Section 4 Field Operations
- Section 5 Practical Exercise
- Section 6 Quality Control
- Section 7 Summary

# Evolution of GPS



- 1978 NAVSTAR
- 1980 Civilian use
- 1995 Full Constellation
- 2000 Selective Availability turned off
- 2005 Additional Bands
- 2010 30-50 cm accuracy

# FEMA use of GPS Information

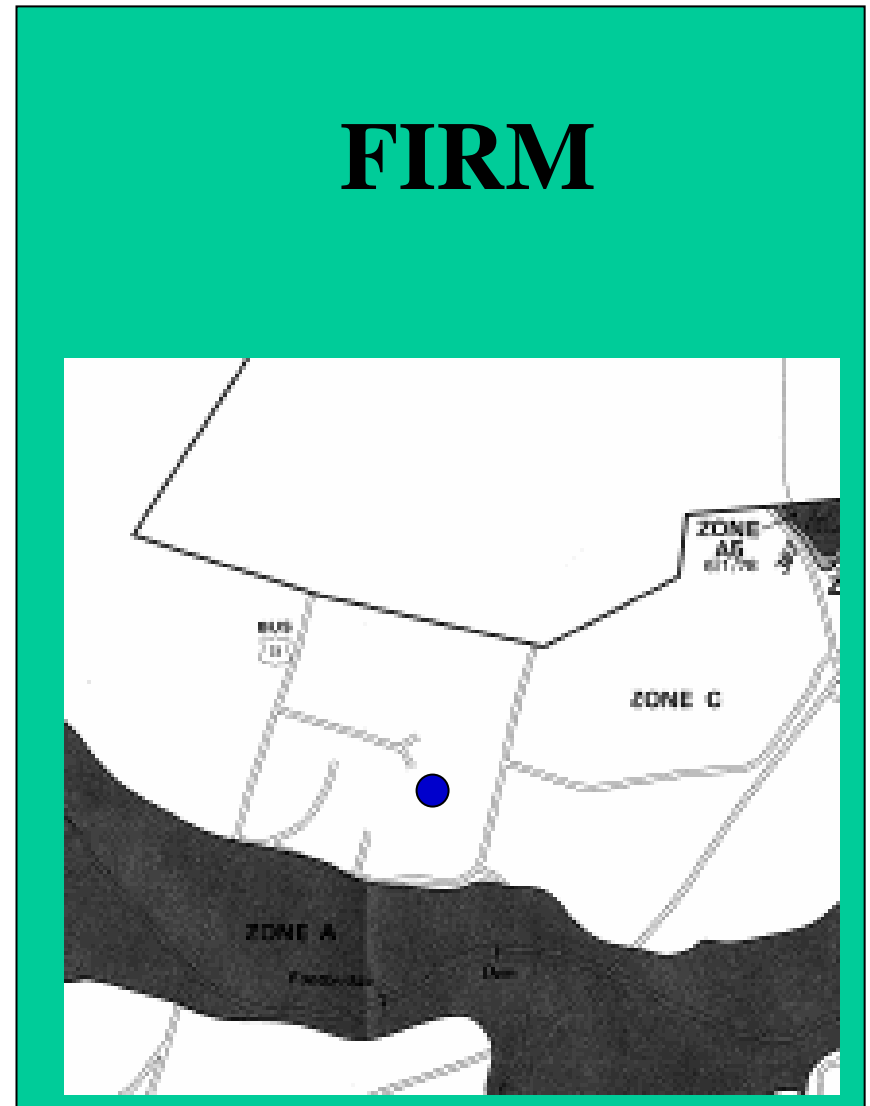
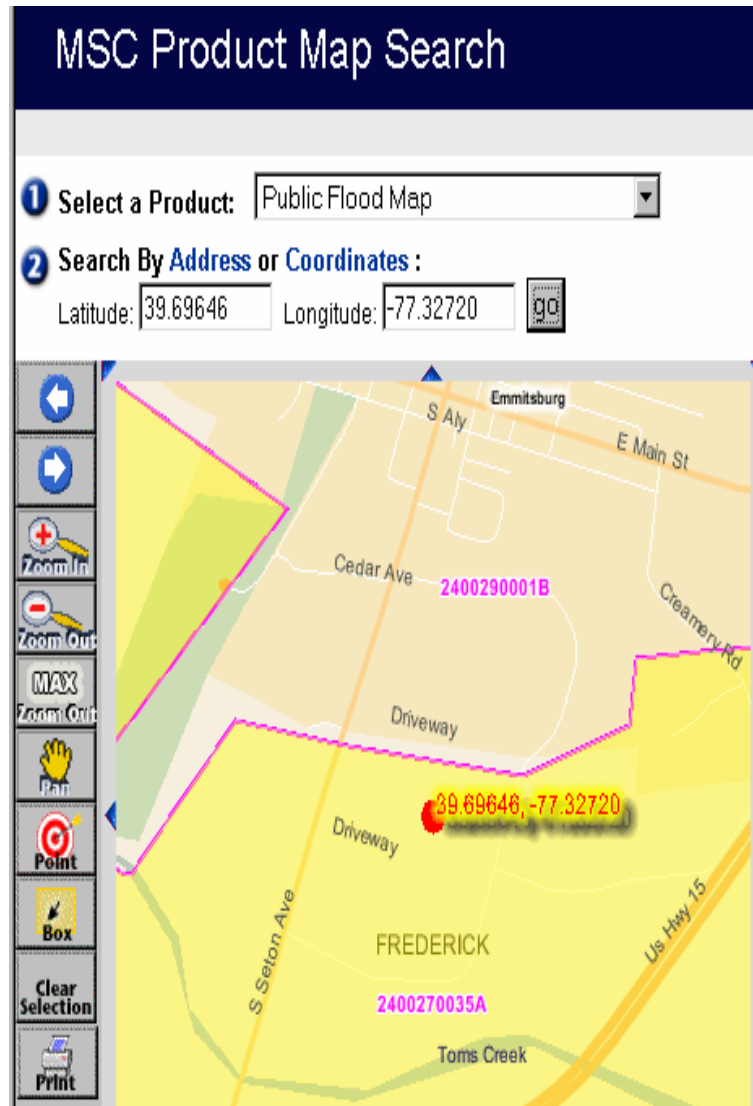
- Often no physical address
- Federal Grants requirement
- Damage location validation
- Special considerations
- Flood Plain mapping
- Repetitive loss rule

# Who uses GPS information?

- Response – PDA
- Public Assistance – Project Worksheet, compliance
- Mitigation – site survey, flood plains
- Historic – Special maps (burial sites, districts)
- Environmental – Special maps (species, wetlands)
- GIS – special projects, creating maps
- Headquarters – long term tracking & analysis

**FEMA Requires Accuracy of 20 Meters**

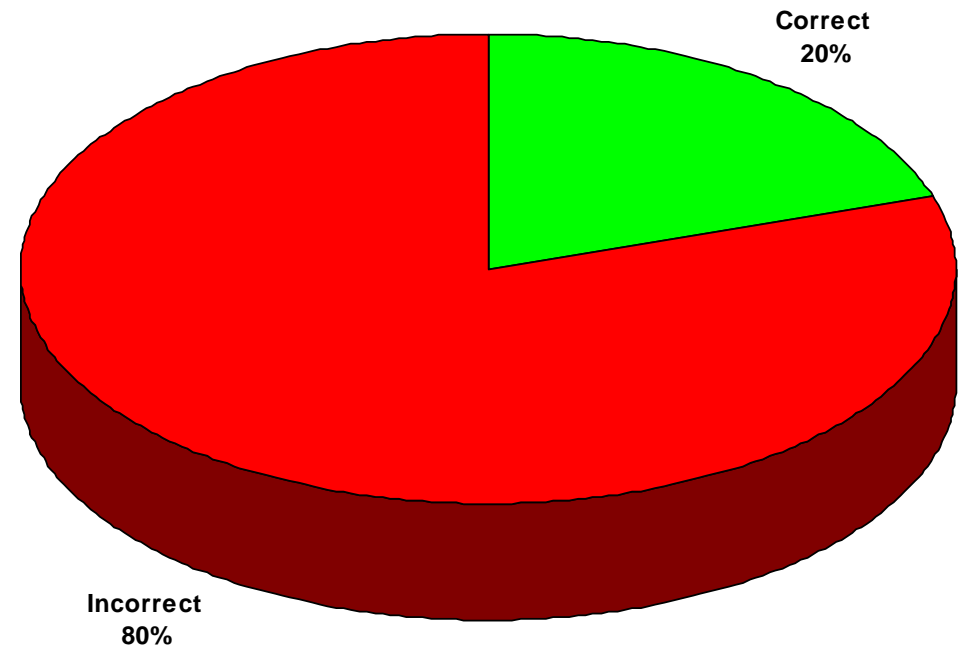
# Example of Use





# Current FEMA Performance

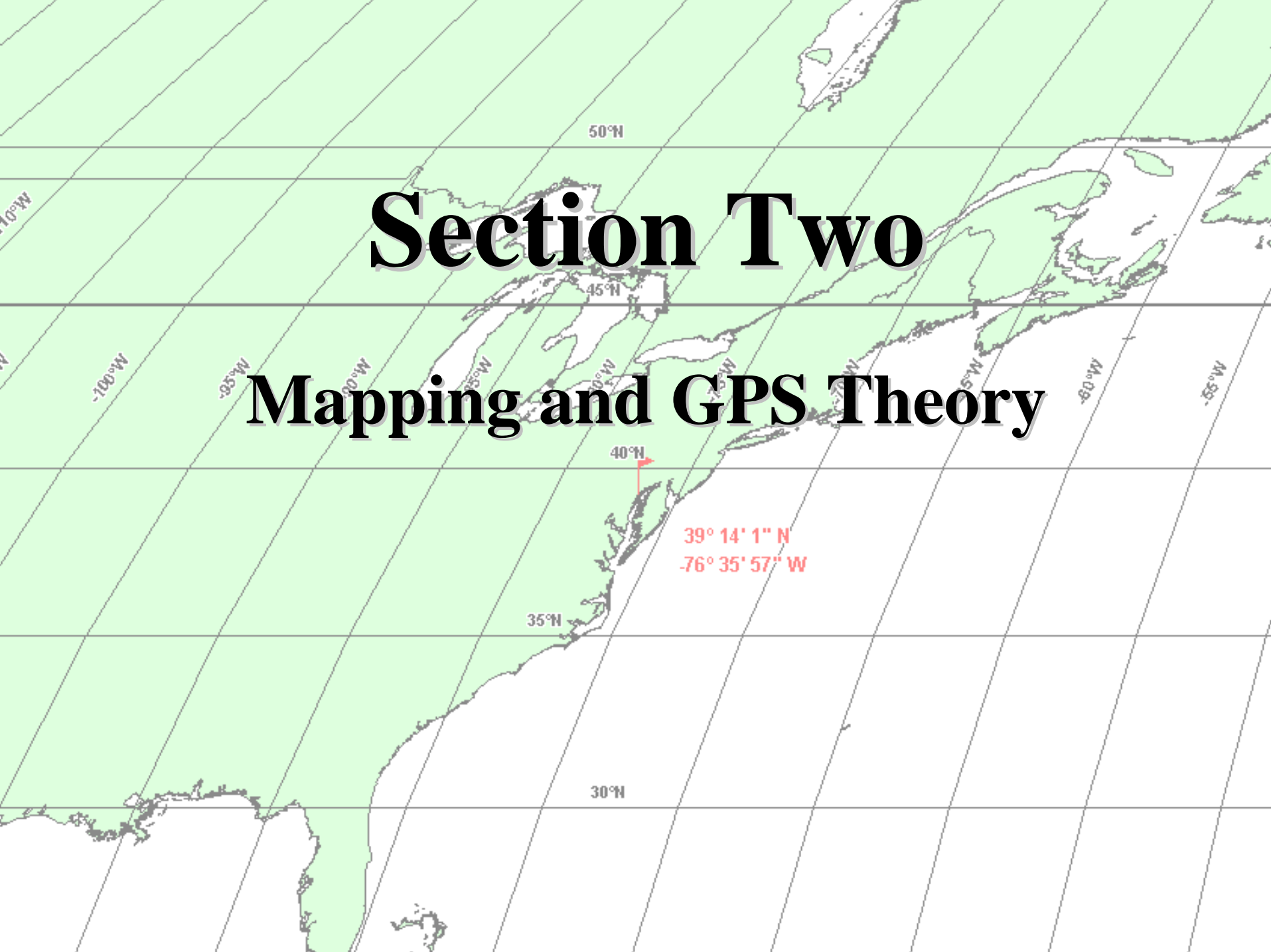
- 20% PW correctly entered coordinates
- Common mistakes
  - Transcription errors
  - Wrongly formatted
  - Bad Conversions



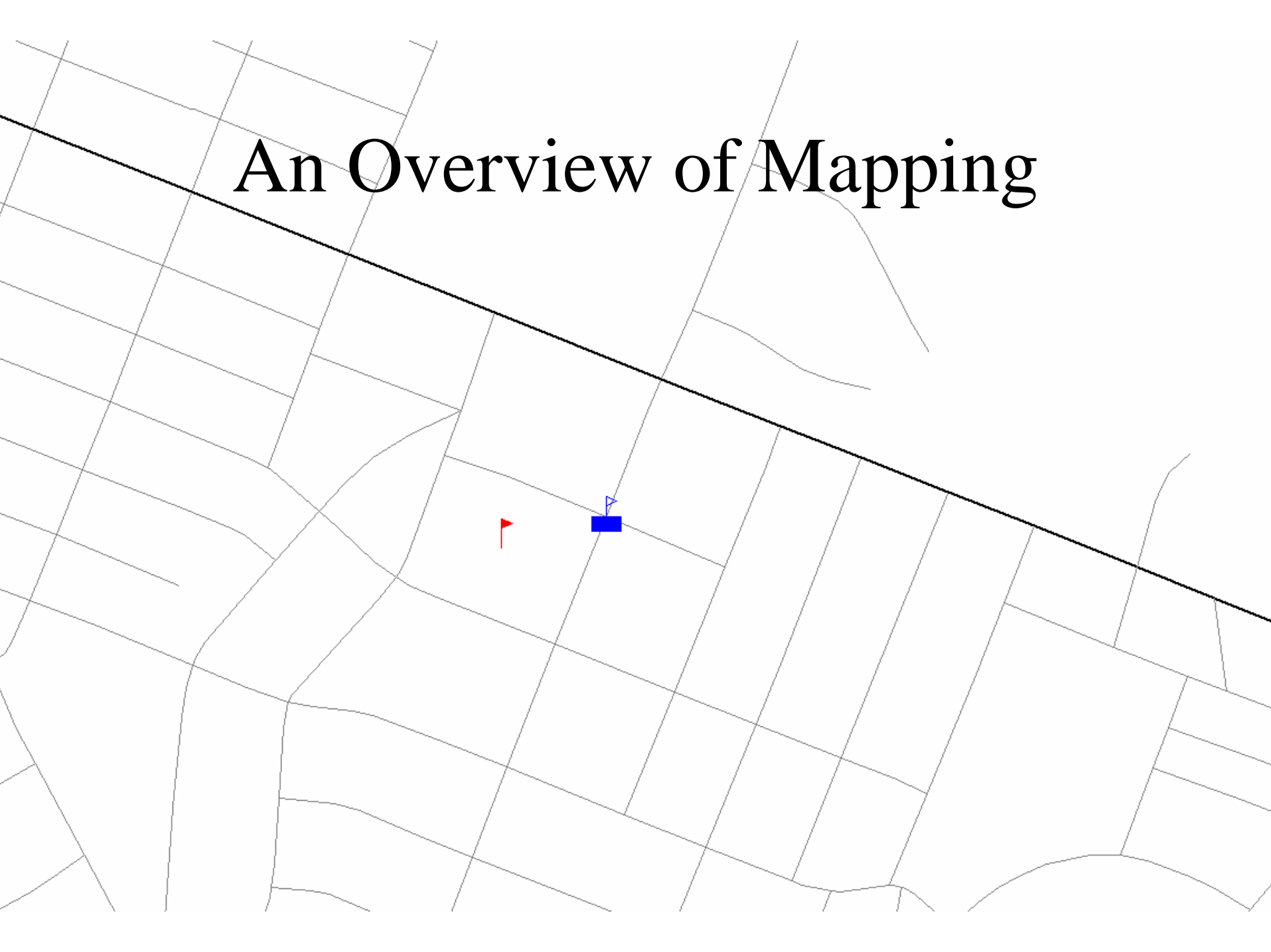
**Target Performance Goal: 95% Correct**

# Section Two

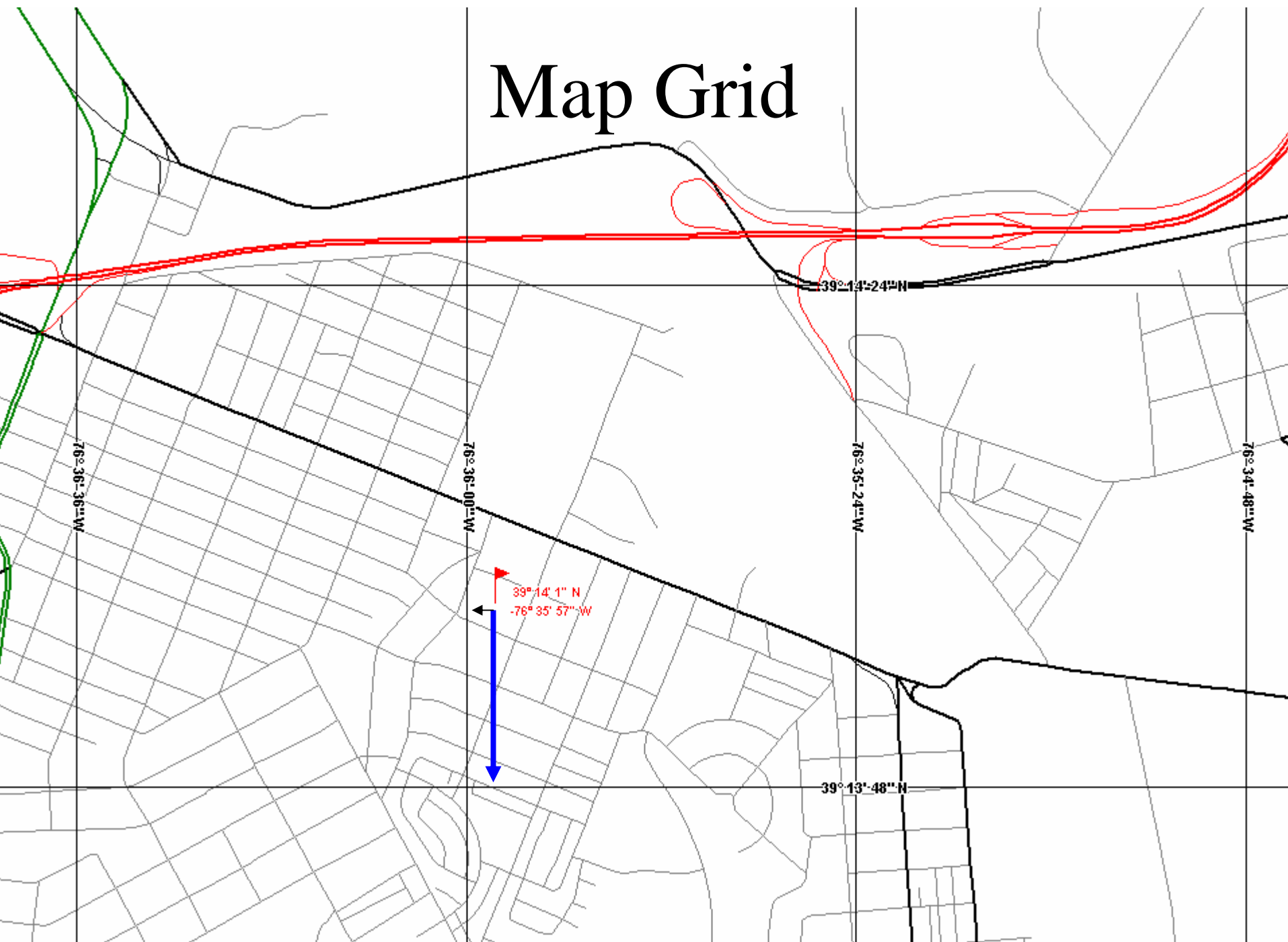
## Mapping and GPS Theory



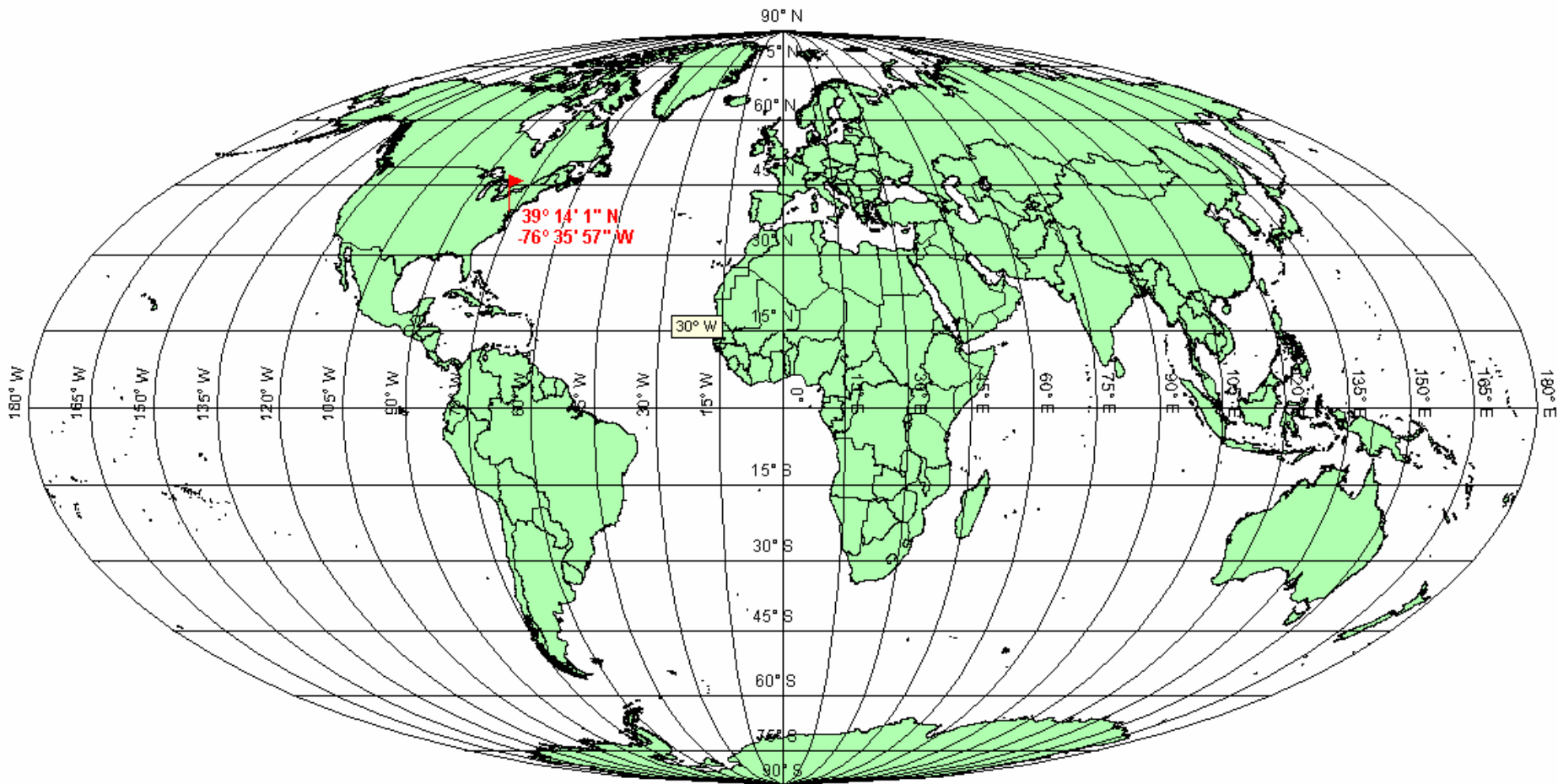
# An Overview of Mapping



# Map Grid



# World View



# Grid Formats

- FEMA Format Decimal Degrees hddd.ddddd°

<b>Location</b>	N 38.04417° W078.49839°
-----------------	----------------------------

- Universal Trans Mercator

<b>Location</b>	17S 0719520 4213669
-----------------	------------------------

- Degrees Decimal Minutes
  - hddd°mm.mmm

<b>Location</b>	N 38° 02.650' W078° 29.903'
-----------------	--------------------------------

- US National Grid

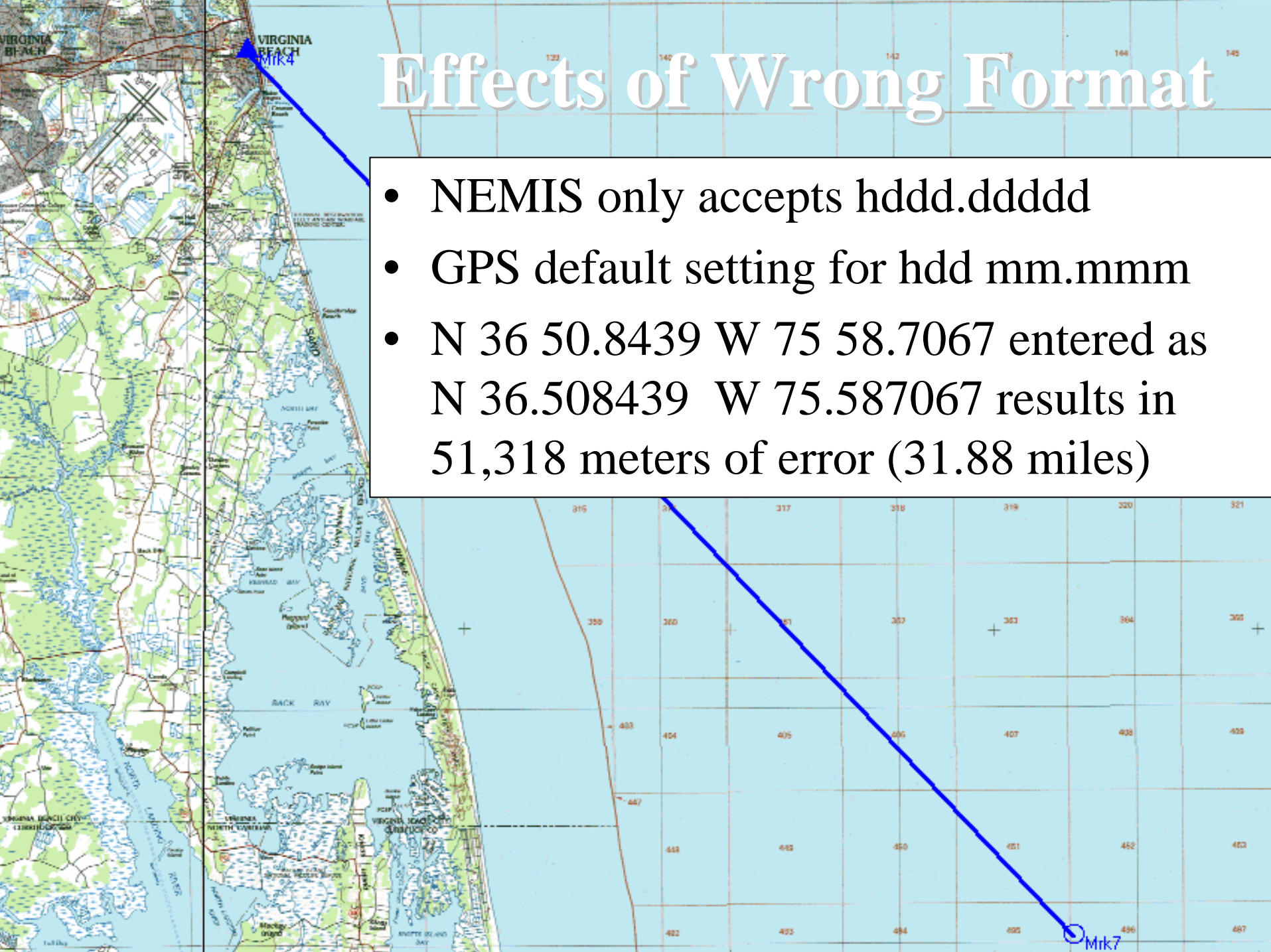
<b>Location</b>	17S QC 19520 MGRS 13669
-----------------	----------------------------

- Degrees, Minutes, Seconds
  - hdd°mm'ss.s''

<b>Location</b>	N 38° 02' 39.0 W078° 29' 53.9
-----------------	----------------------------------

# Effects of Wrong Format

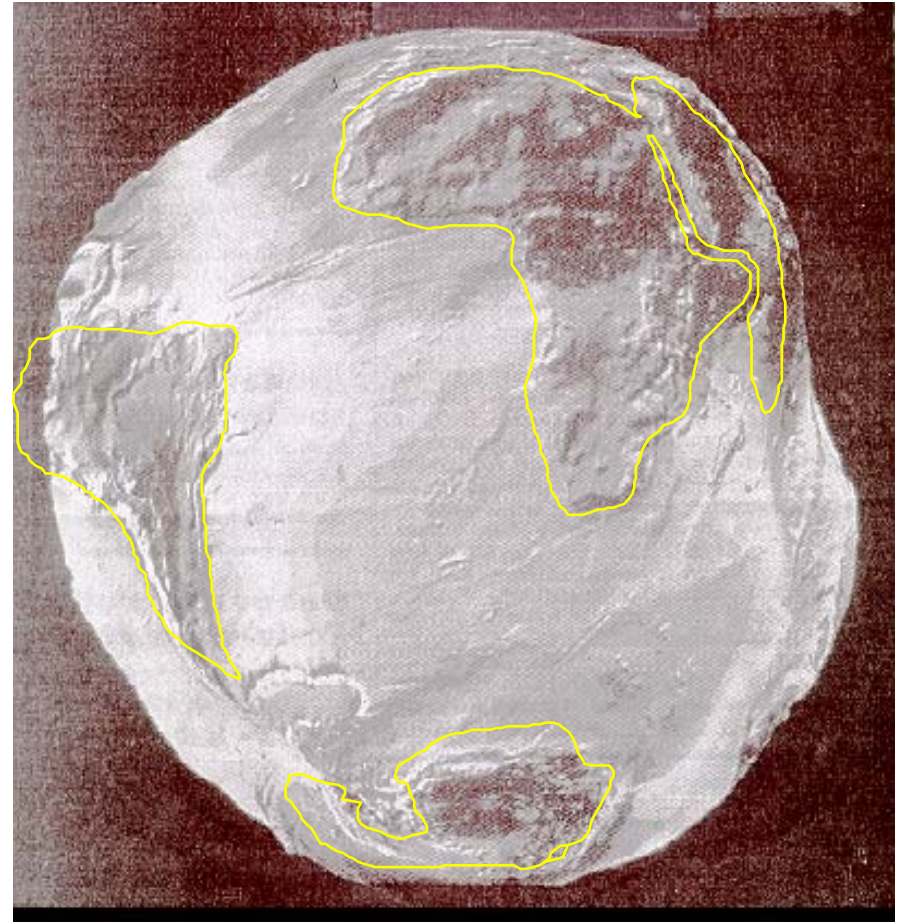
- NEMIS only accepts hddd.ddddd
- GPS default setting for hdd mm.mmm
- N 36 50.8439 W 75 58.7067 entered as N 36.508439 W 75.587067 results in 51,318 meters of error (31.88 miles)





# Datums- another user error

- Default setting is for NAD83 or WGS84
- NAD27 is older
- What is a datum
  - Start point for model
  - Mathematical model of earth – ellipsoid
  - World not round

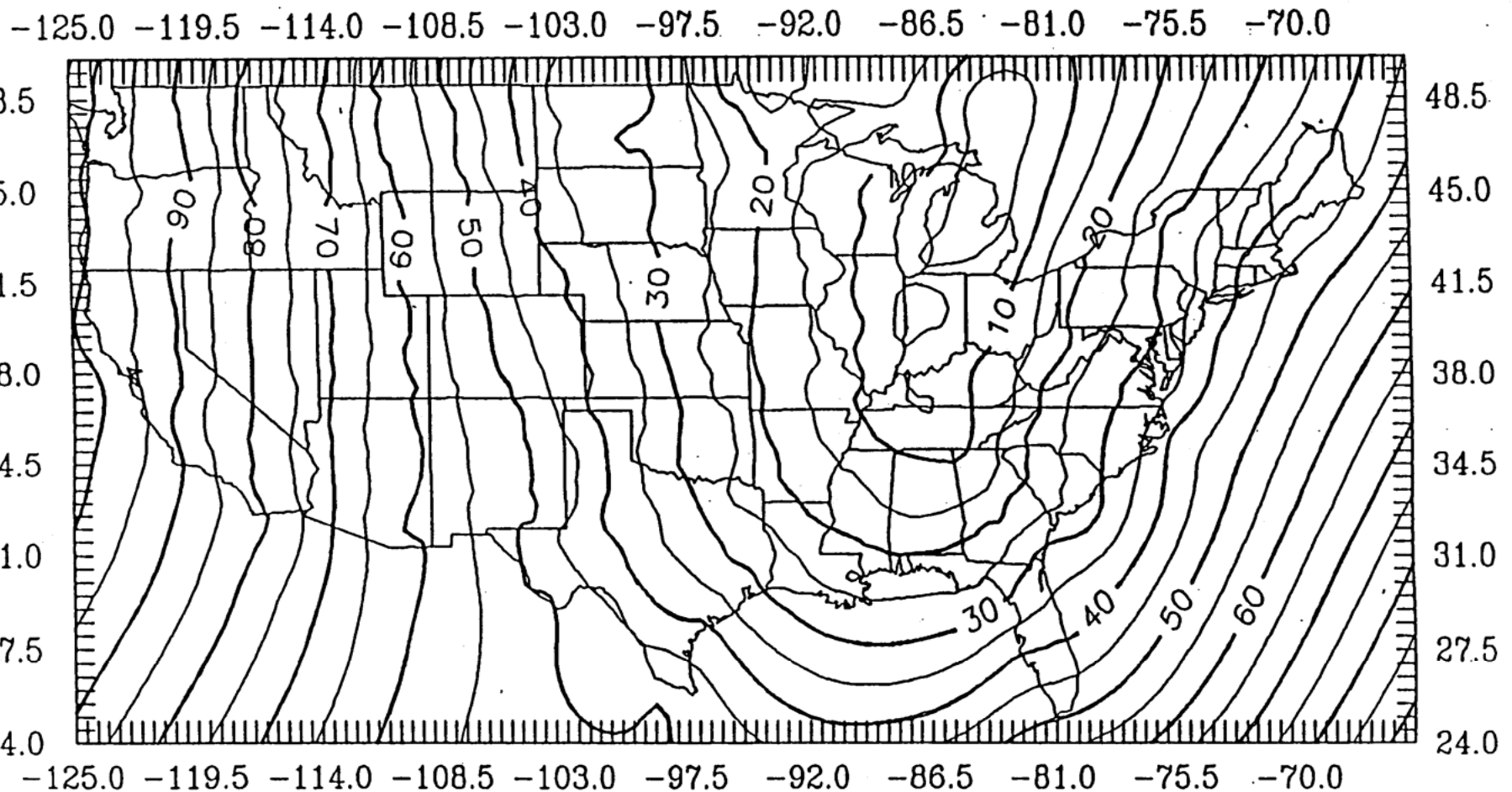






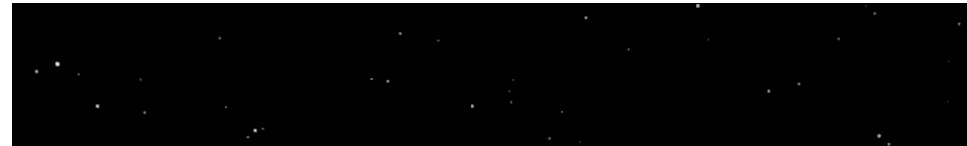
# NAD 27 and NAD 83

## MAGNITUDE OF DATUM SHIFT (METERS)

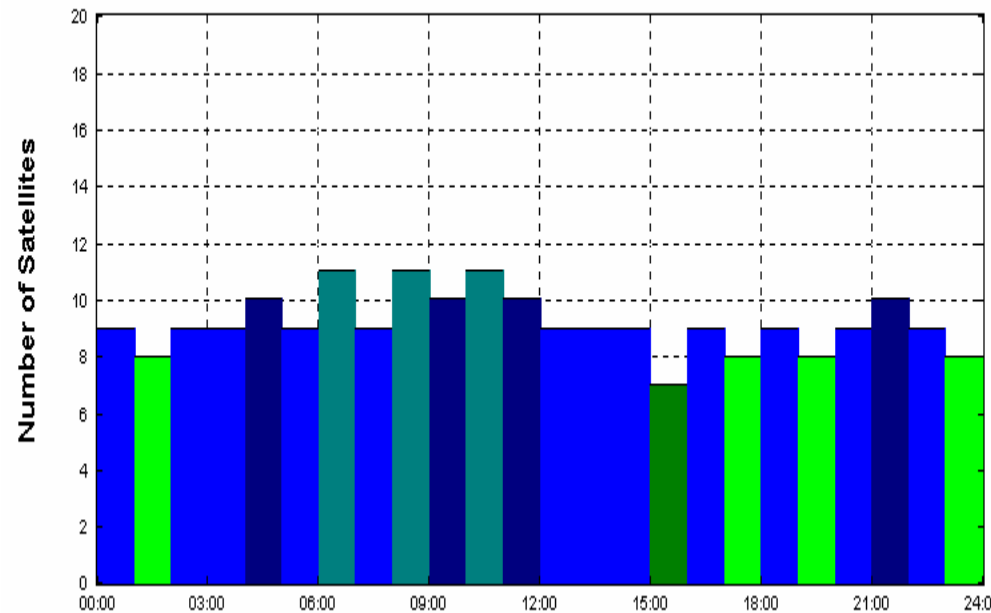


# GPS – How does it Work?

- Constellation of 24 + satellites
- 6 different orbits
- 20,200 km above earth
- Able to see at least 4 at any given time

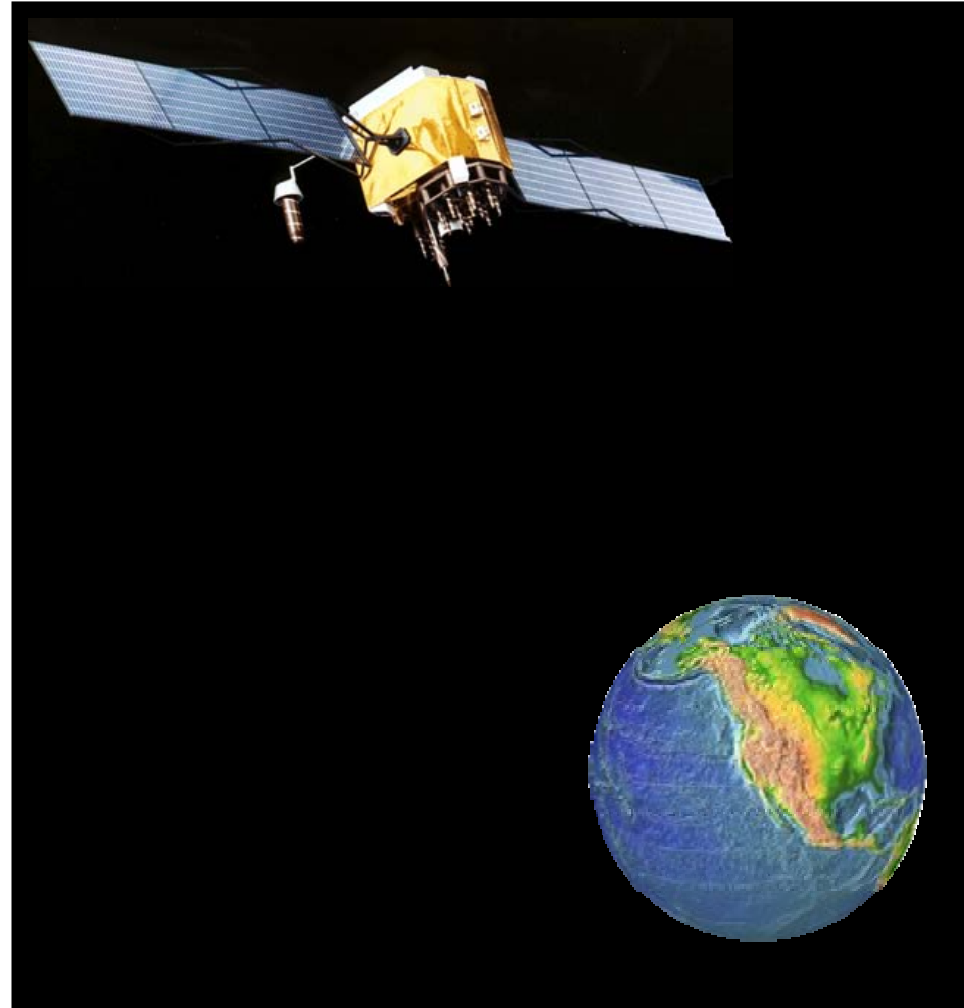


*Visibility*



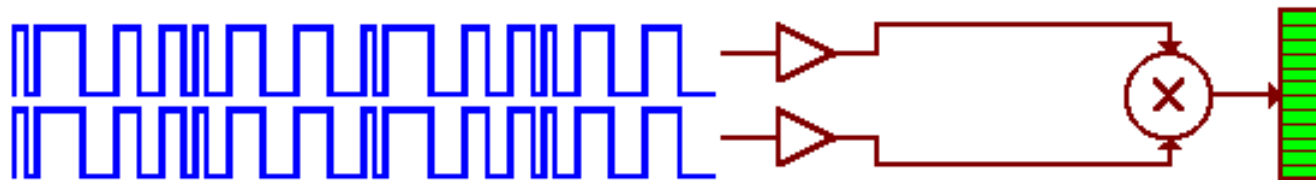
# The Signal from the Satellite

- Microwave Radio Frequency
- Effective Output 500W
- Line of Sight
- Pass through clouds, glass, plastic
- Blocked by buildings, mountains, etc.
- Weaker signals under trees



# Signal Components

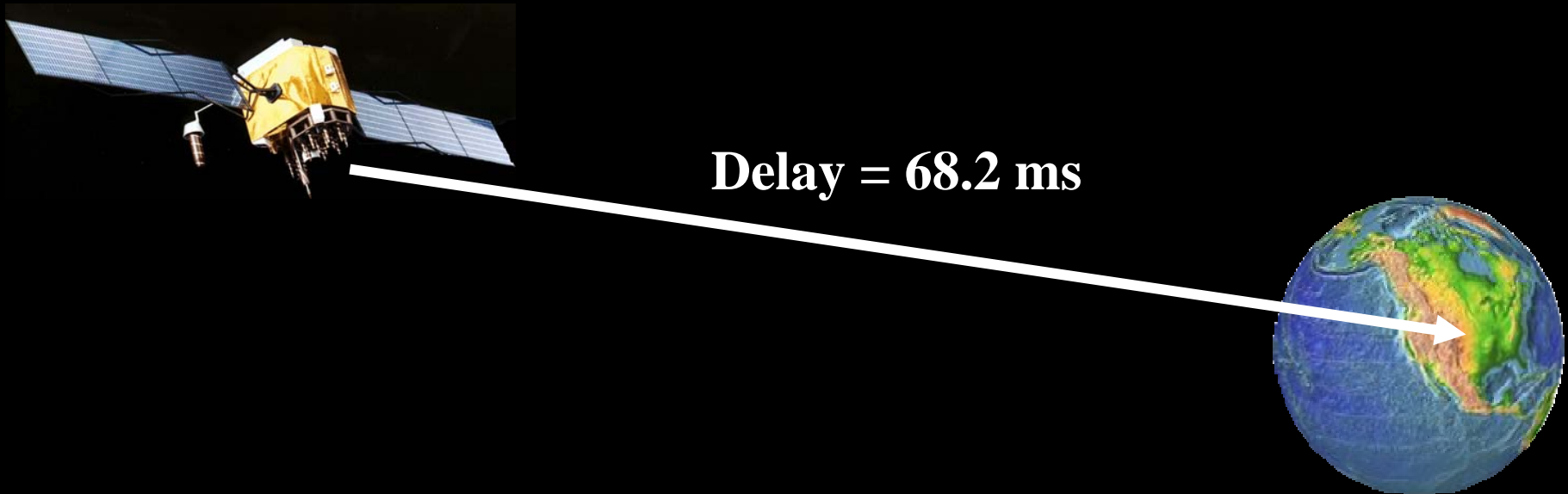
- Almanac (telemetry) updated location of all satellites
- Unique Satellite identification code
- Pseudorandom noise code – similar to a song
- Alignment of PRN code allows GPS receiver to determine time delay



Offset = 68.2 milliseconds

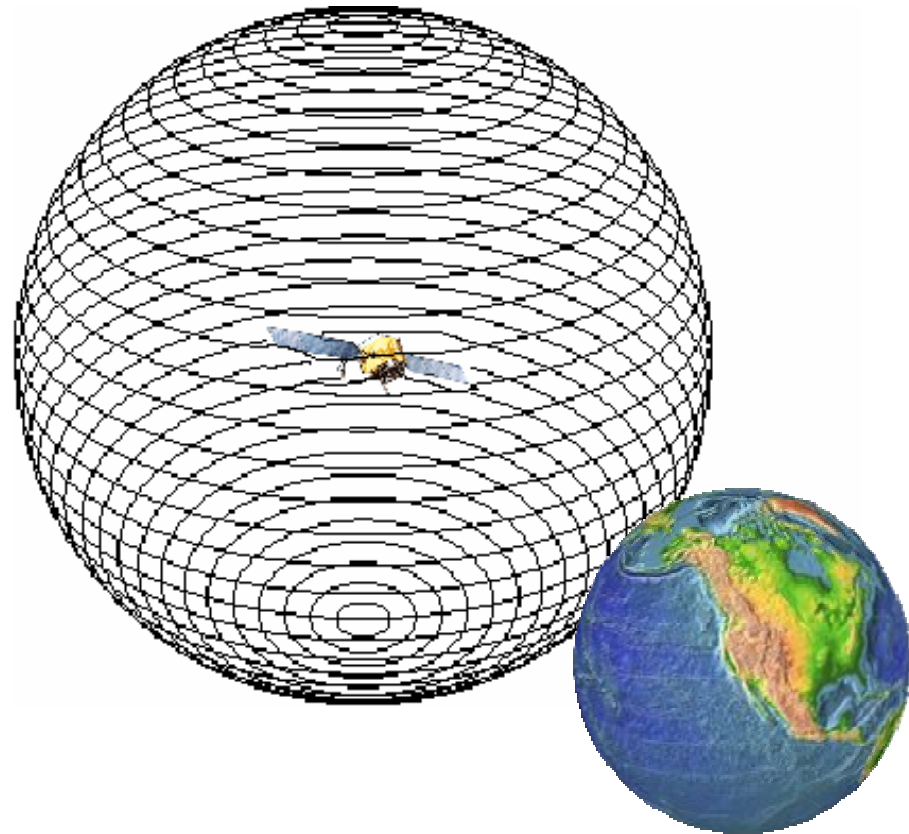
# Time Delay = Distance

- Signal travels at speed of light ( $c$ )
- Time delay  $\times c =$  distance
- If delay = 0.0682 s then distance = 20,446 km



# Time Delay = Distance

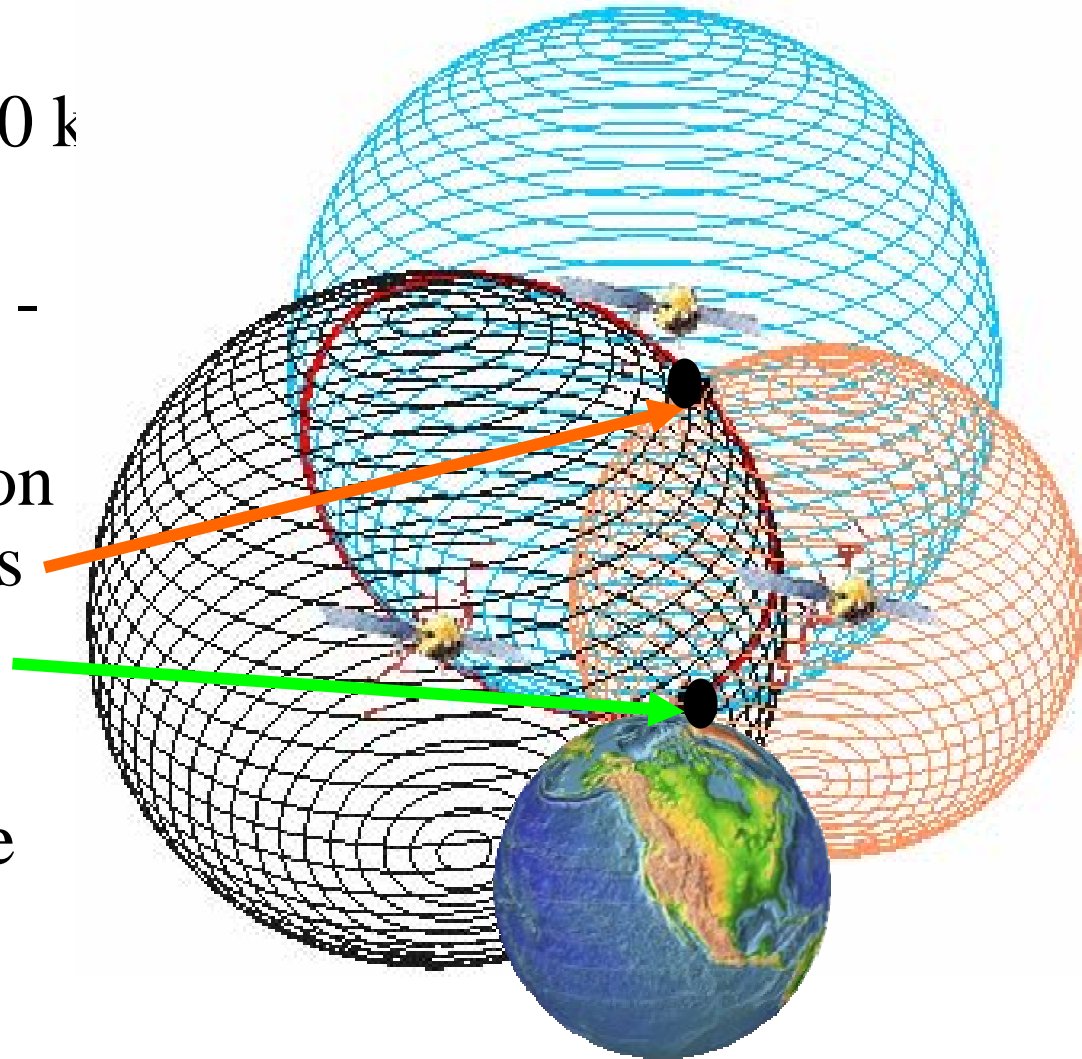
Therefore, we know we are  
located on a sphere 20,446  
km from satellite



# GPS Trilateration

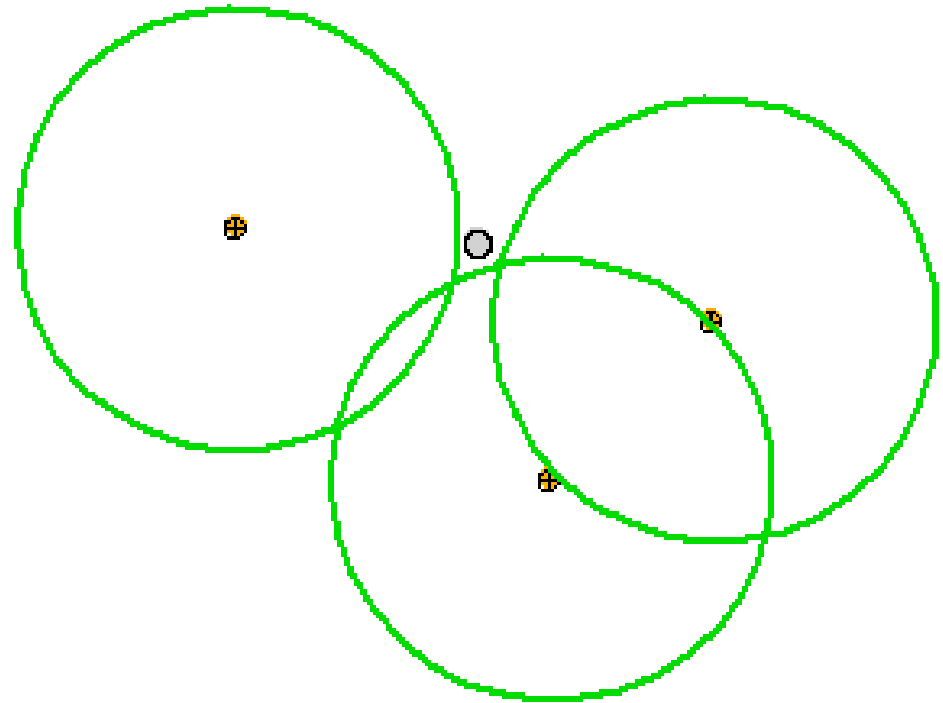


- Second satellite is 24,000 km away
- Intersection two spheres - circle
- Third satellite intersection gives two possible points
- One point near earth's surface
- Determines Pseudorange



# Time Correction

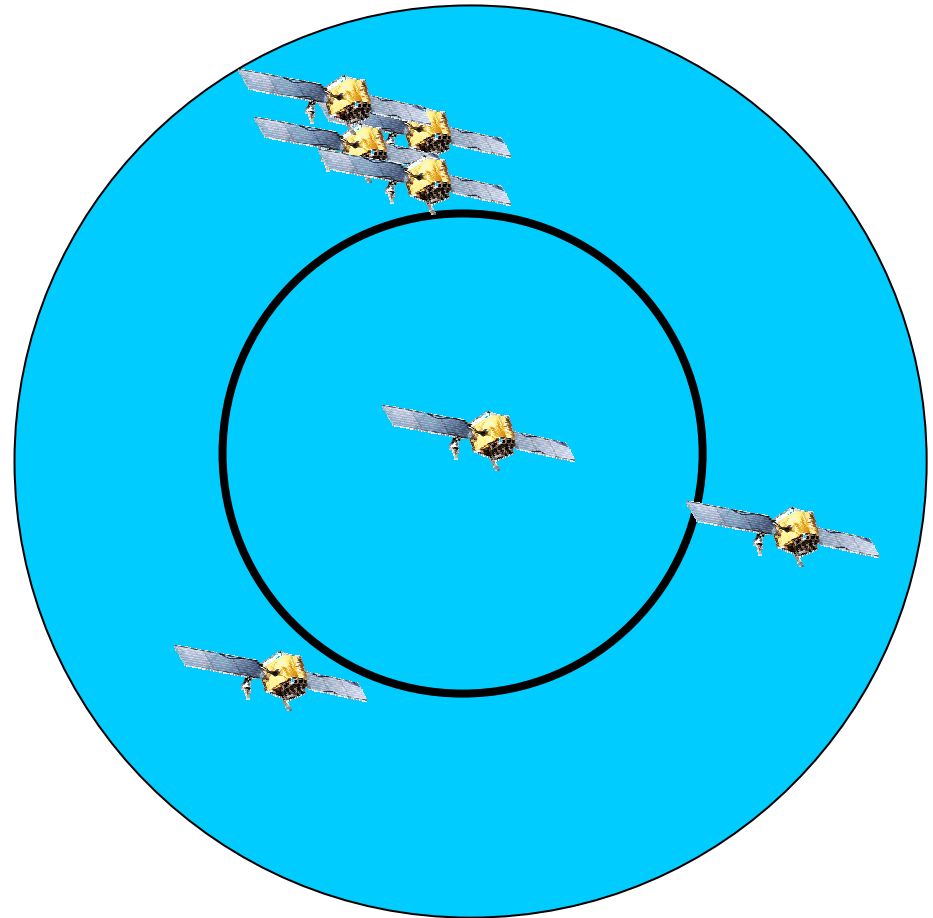
- Error of 1/1000 second = 186 m
- Atomic Clocks used in Satellites
- Quartz Clock in GPS receiver
- Needs to be corrected
- Corrected by seeing fourth satellite





# More Satellites are Better

- Receiver selects best signal
- Geometry affects accuracy
- Watch satellite page
- If accruing signal from additional satellites good to wait
- Able to watch accuracy improve



# Sources of Error

Error Source	Typical Error	DGPS Error
Selective Availability*	100 M	-
Ionosphere	10 M	-
Troposphere	1 M	-
SV Clock	1 M	-
SV Orbit	1 M	-
Pseudo – Range Noise	1 M	1 M
Receiver Noise	1 M	1 M
Multipath	0.5 M	0.5 M
<b>TOTAL ERROR</b>	<b>15 M</b>	<b>3 M</b>

# Precision vs Accuracy

- 0300,4396 defines a 1000 meter box
- 03003,43960 defines a 100 meter box
- 030039,439609 defines a 10 meter box
- 0300391,4396091 gives a 1 meter box
- Garmin Etrex gives 1 meter precision



# Precision vs Accuracy

- Unit precise to 1 meter

**BUT**

- Accurate to 100 meter when selective availability turned on
- Accurate to 15 m under normal conditions
- Accurate to 3 m if WAAS signal obtained



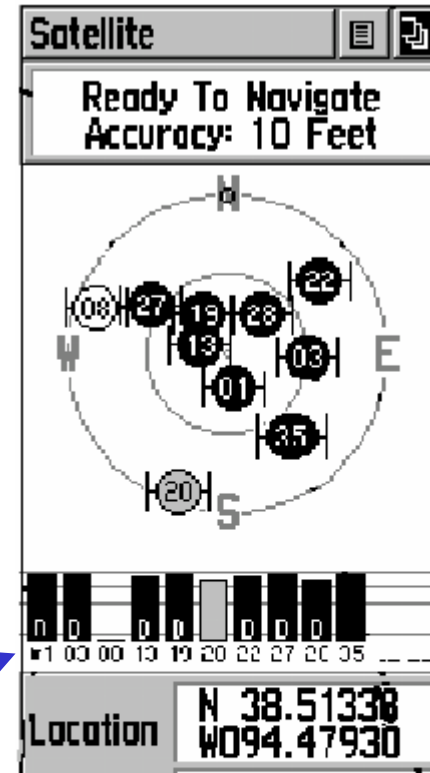
# dGPS - WAAS

- dGPS able to reduce several errors (<3m accuracy)
- Receiver able to pick up dGPS signal called WAAS
- WAAS explanation



# Can you tell if you have dGPS?

- Newer versions of GPS units are WAAS enabled
- Garmin Etrex series indicates differential data downloaded by a “D” on Satellite page.
- Accuracy improves



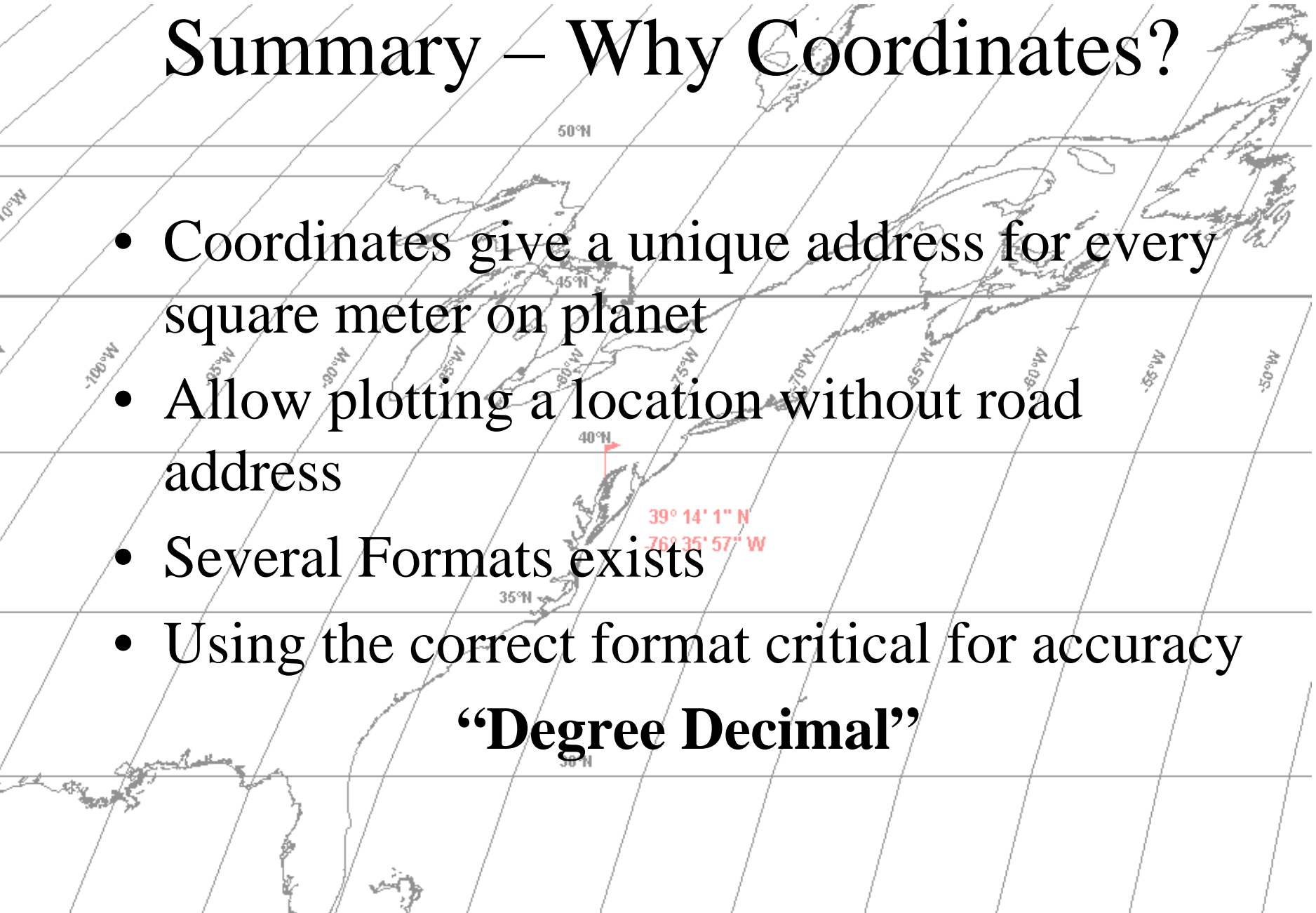
*Satellite Page  
with 9 Satellites Being  
Tracked and WAAS Enabled.  
WAAS Satellite is No. 35  
and 'D' in Signal Bars for  
GPS Satellites*



# Summary – Why Coordinates?

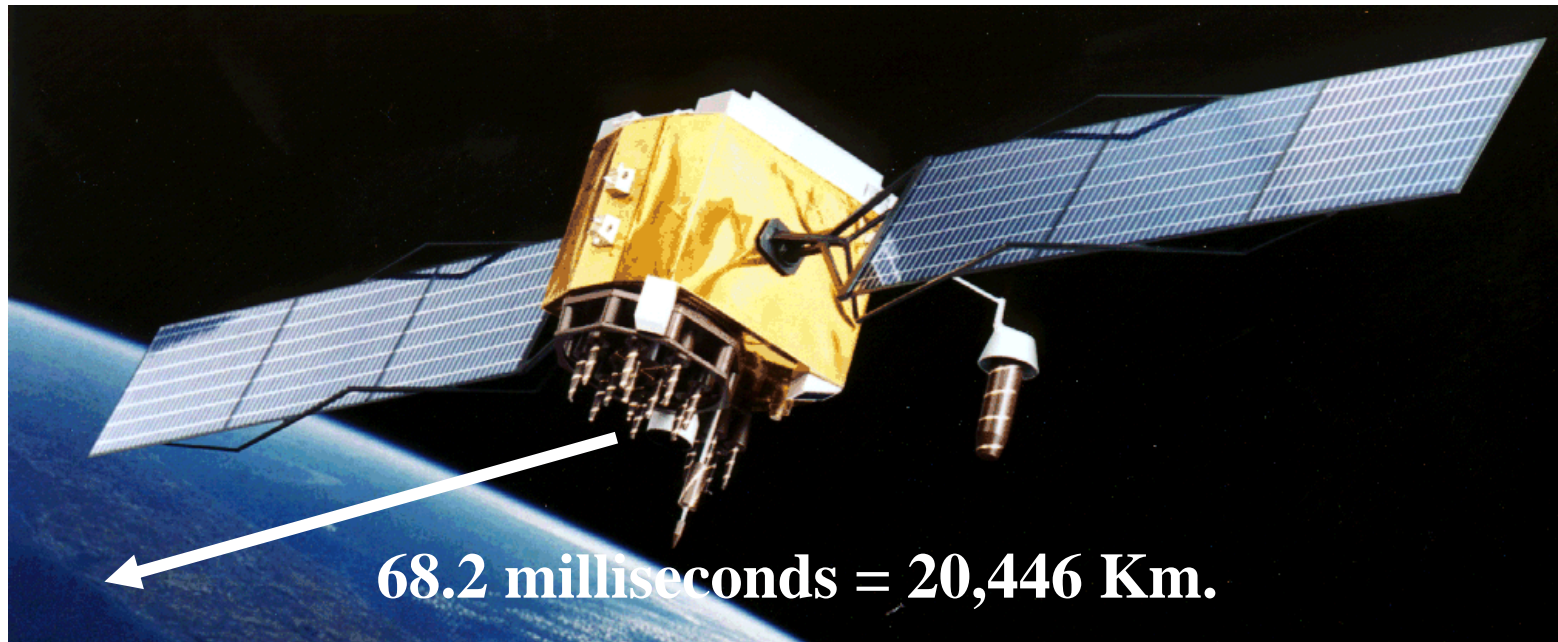
- Coordinates give a unique address for every square meter on planet
- Allow plotting a location without road address
- Several Formats exists
- Using the correct format critical for accuracy

**“Degree Decimal”**



# Summary – How GPS Works

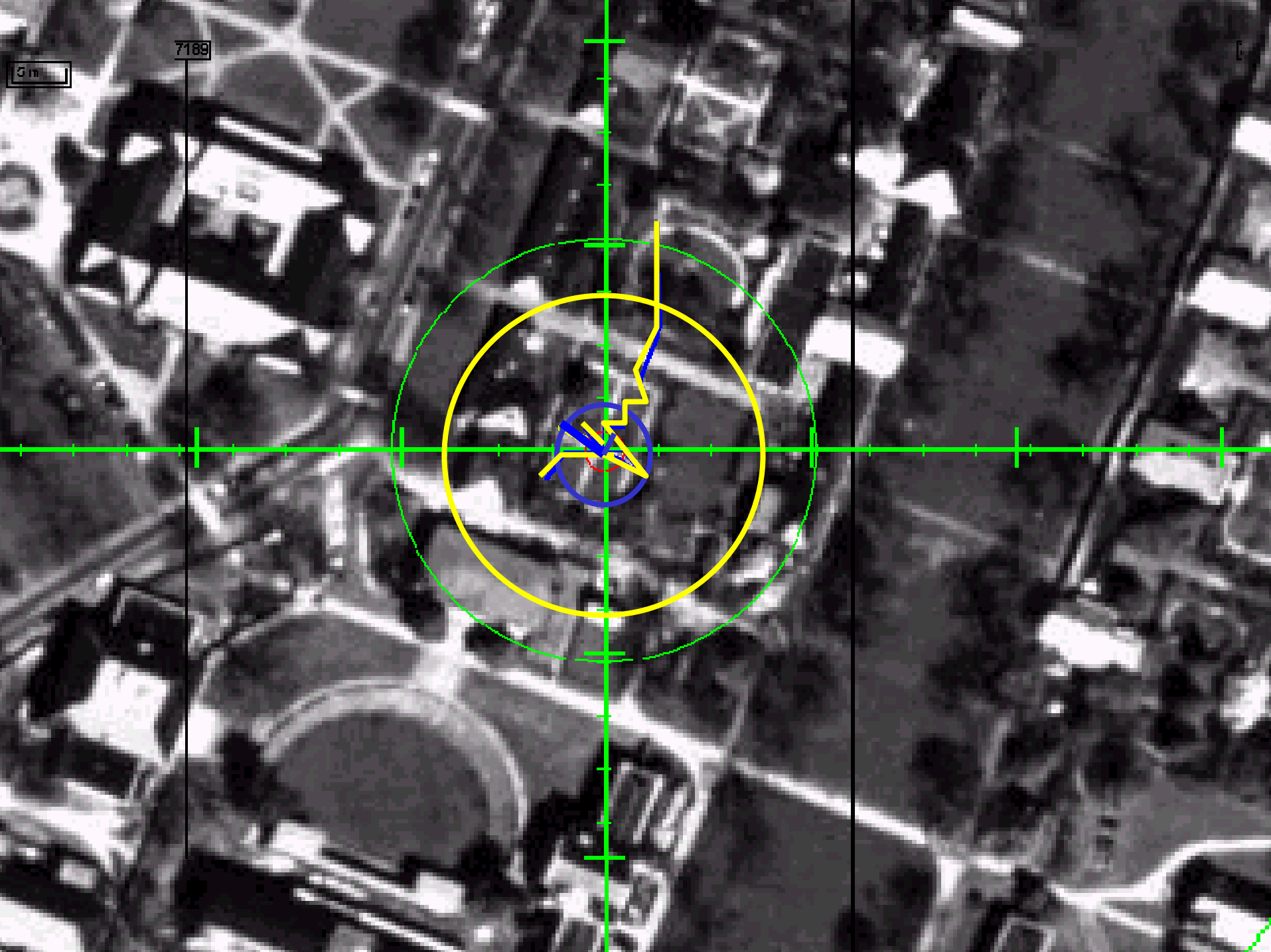
- Obtain radio signal from GPS satellite
- Measures time it takes for signal to reach earth to determine distance
- With four satellites can determine location





# Summary – Improving Accuracy

- See more satellites (15 meters)
  - Open area
  - Wait to lock on
  - Wait for better Geometry
- Obtain differential Signal (3 meter)



7189

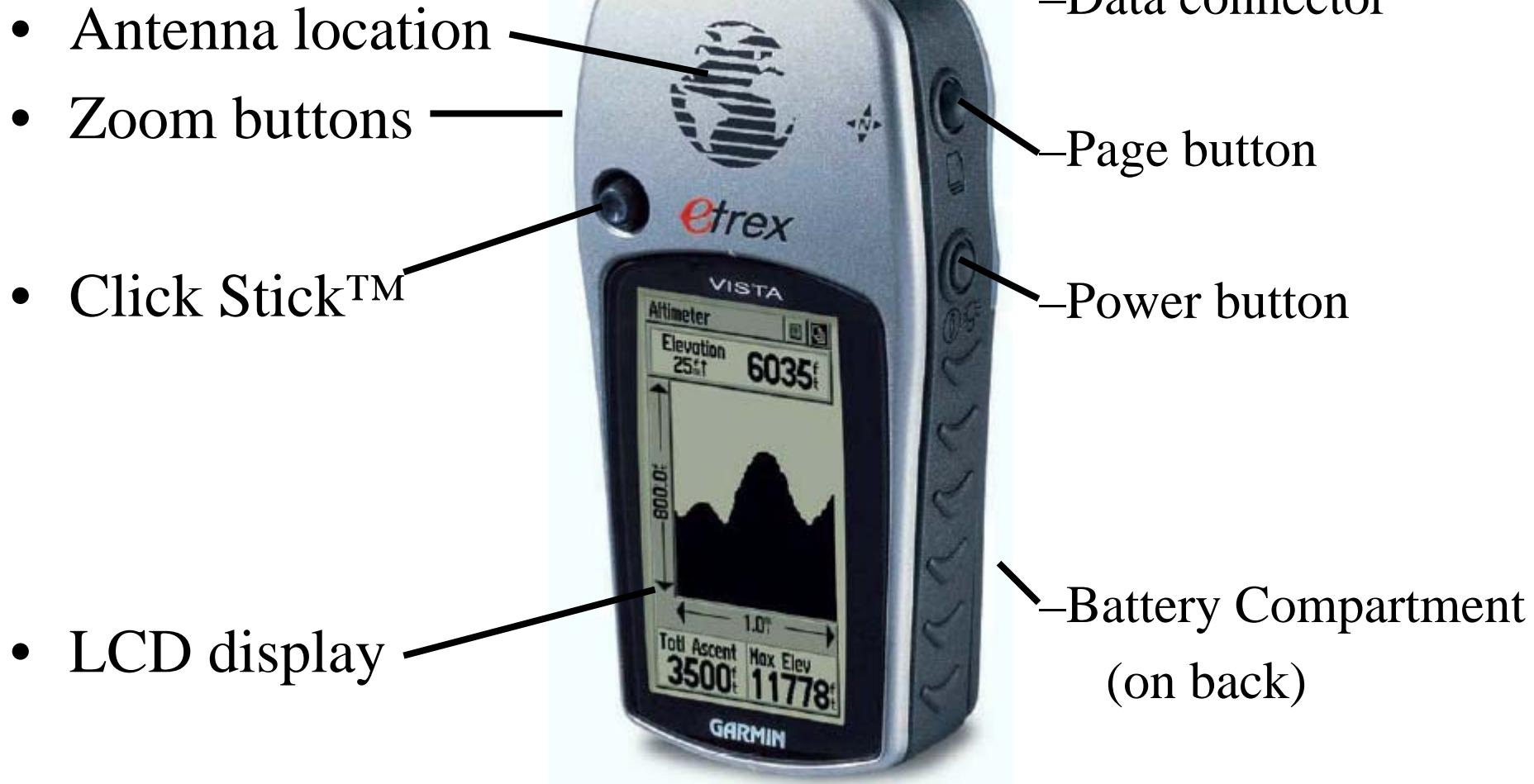
5 m

# SECTION THREE

## Features



# Features of eTrex Vista™



# Installing Batteries

- Two AA last for 12 hours
- Turn-off when between work sites
- Bring extra batteries
- Battery indicator



# Using Button Functions



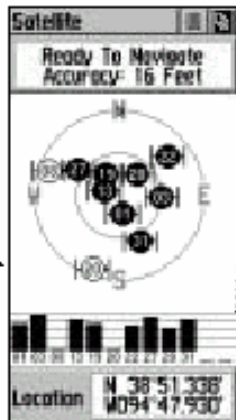
- Power Button
  - Turning on
  - Turning off
  - Light
- Page
- Zoom
- Click Stick

# Notification Message

- After turning GPS on
- If inside – unable to find any satellites
- Error Message appears
- Acknowledge by using Click Stick™.



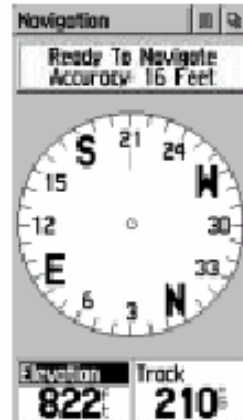
# Previewing Main Pages



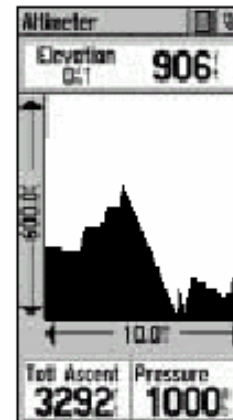
Satellite Page



Map Page



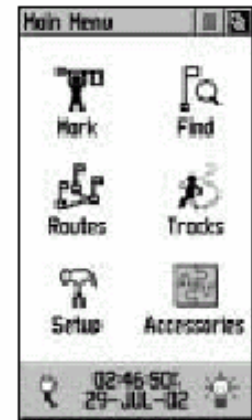
Navigation Page



Altimeter Page



Trip Computer

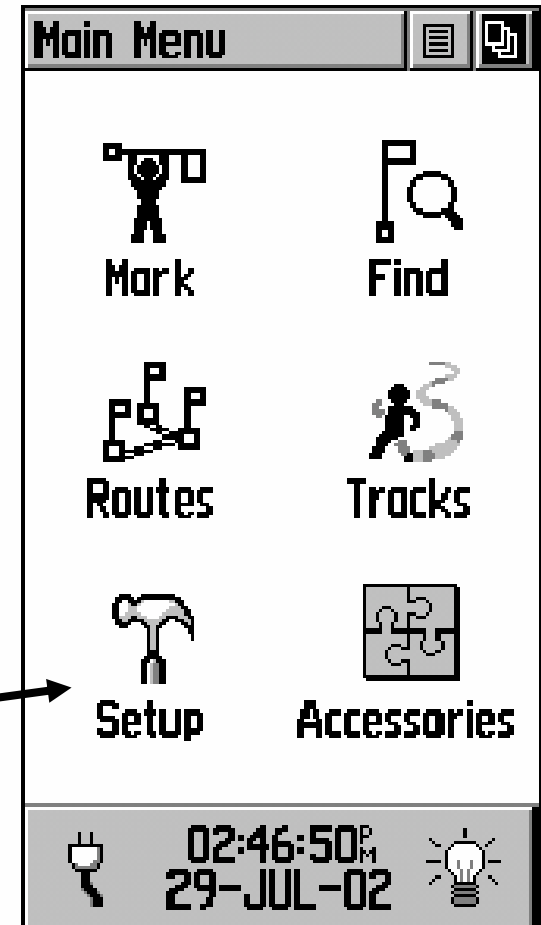


Main Menu



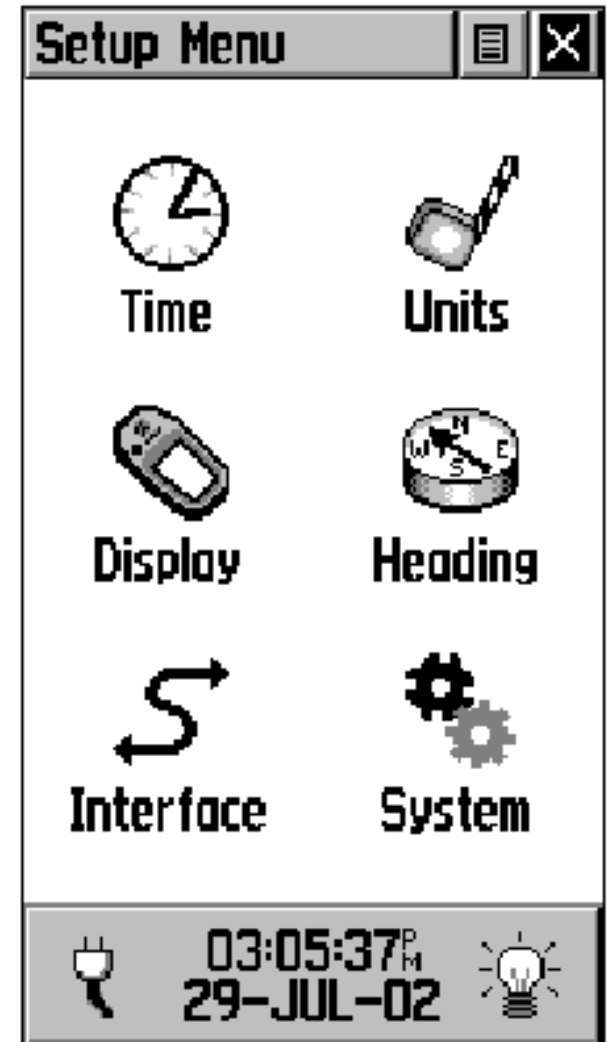
# Main Menu

- Reached by page button
- Use Click Stick to move within page
- Need to configure/check settings when issued GPS
- All configurations changes/checks from **Setup** page.



# Setup Menu

- Six Options/Icons
- We will discuss
  - Units
  - System
  - Time



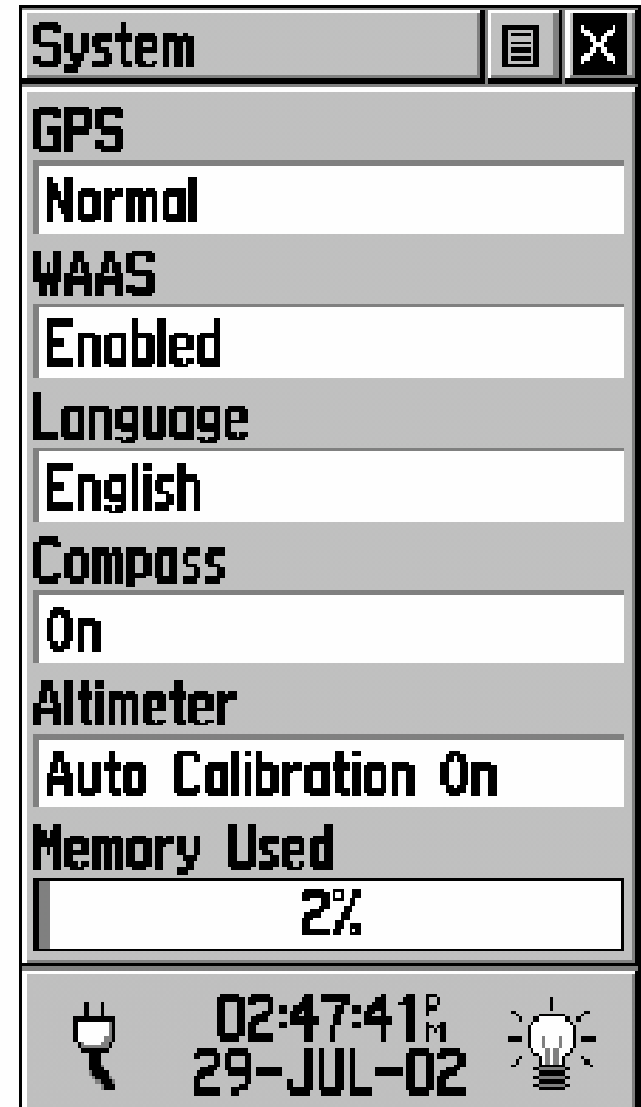
# Units

- Position Format
  - hddd.ddddd
- Map Datum
  - WGS 84 or NAD83
- Distance Speed
  - English Units

Units	
Position Format	
hddd.ddddd°	
Map Datum	
WGS 84	
Distance/Speed	
Yards	
Elevation	Vertical Spd
Feet	ft/min
Depth	
Statute	
Pressure	
Millibars	
03:04:30 <sup>P</sup> 29-JUL-02	


# System

- GPS
  - Normal
  - Always switches to normal after being turned off.
- WAAS
  - Enabled



# Time

- Minutes and seconds are downloaded from the satellite
- Accurate as atomic clock
- Hours must be set to time zone.



The image shows a screenshot of a 'Time' settings window. The window has a title bar with the word 'Time' and standard window controls. The settings are organized into sections with labels and input fields:

- Time Format:** The input field shows '12 Hour'.
- Time Zone:** The input field shows 'US - Central'.
- UTC Offset:** The input field shows '-06hrs00min'.
- Daylight Savings Time:** The input field shows 'Auto'.

At the bottom of the window, there is a status bar containing a plug icon, the current time '03:06:31<sup>PM</sup>', the date '29-JUL-02', and a lightbulb icon.

# Section Four

## Field Operations



# GPS Safety Tips

- Turn off while driving
- Do not place on dash
- Be aware of potentially dangerous conditions
- Avoid dangerous atmospheres



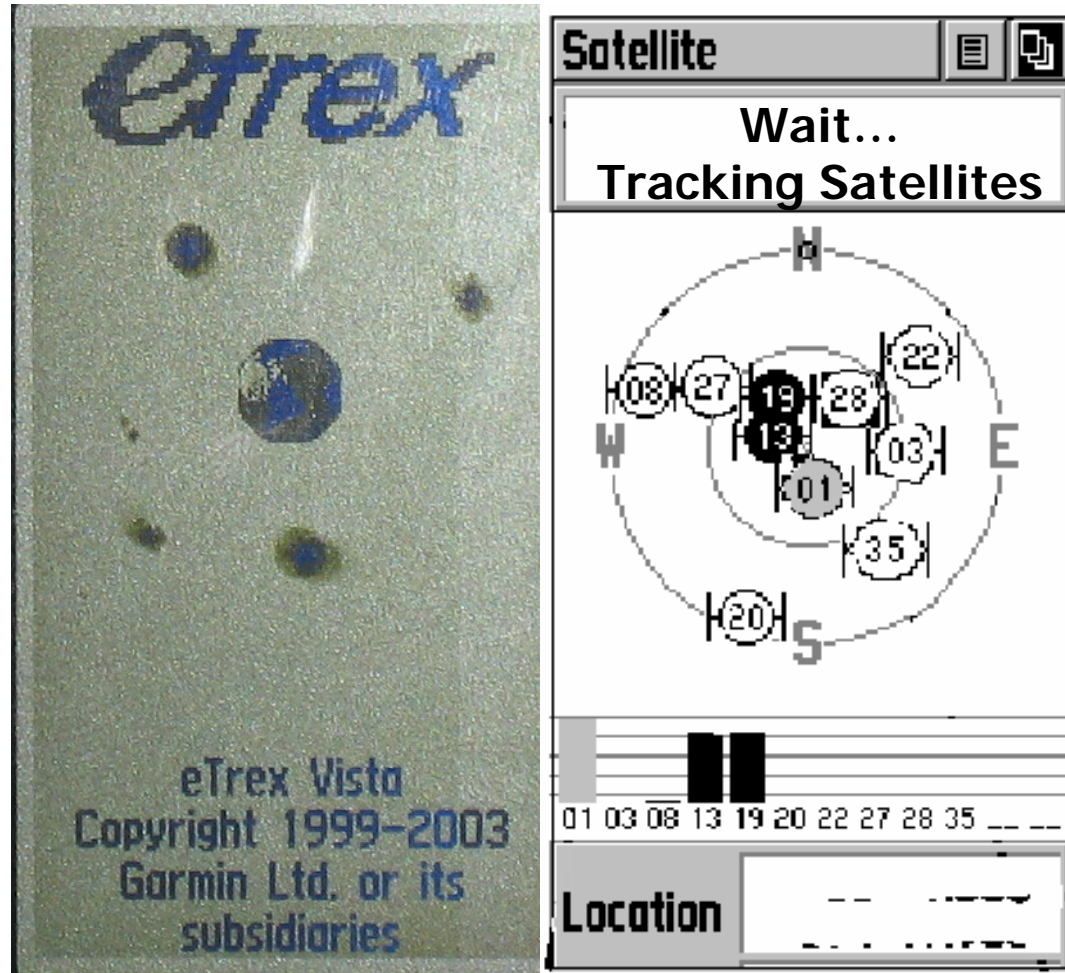


# Start-Up Location

- Travel to site
- Find a safe initial location
- Flat and level
- Open Area – Clear view of sky
- Stationary

# Start-Up Sequence

- Press and hold power button
- Press Page button twice
- Satellite page



# Time to Acquire Reading

Start Condition	Description	Time
<b>Hot</b>	On within 4-6 hours	15 – 30 seconds
<b>Warm</b>	Within 500 miles	45 seconds
<b>Cold</b>	Moved over 500 miles	5 minutes*

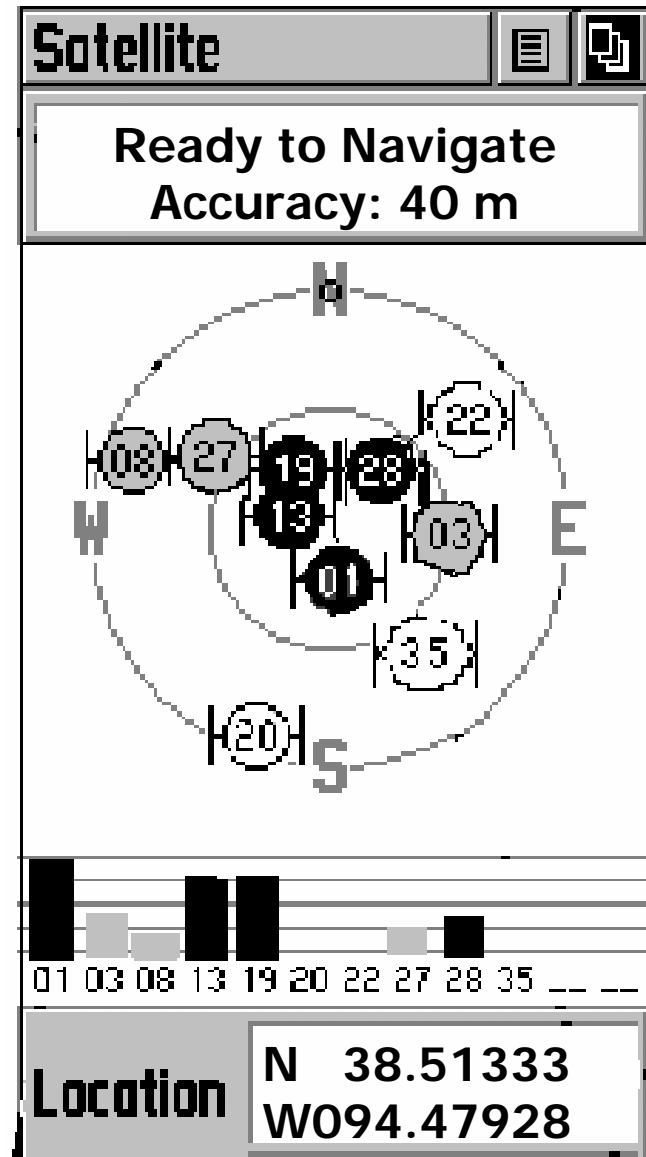
# Cold Starts

- Allow unit to attempt on startup (5 minutes)
- On Poor Satellite window choose new location. Then map
- Scroll triangle to location. Press ENTER
- Wait, try second location



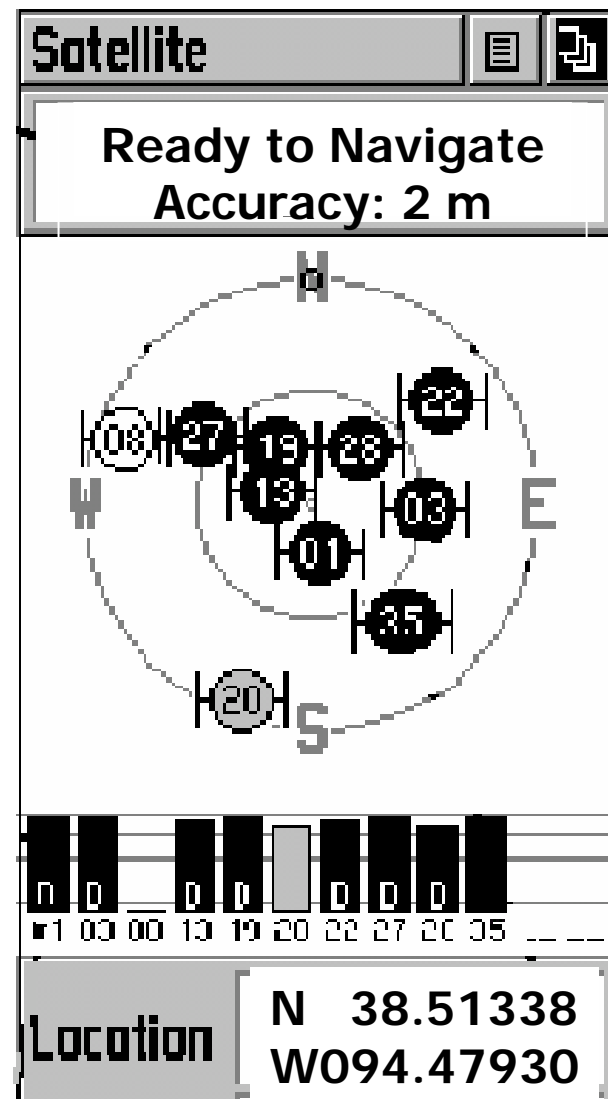
# Satellite Page

- Status Window
- Constellation
- White, Grey, Black circles
- Signal Strength bar
- WAAS info
- Location/coordinates



# After initial location reading

- Accuracy improves with time
- Walk around
- Observe constellation
- Wait for better geometry



# Where to take readings

- Safe location at site
- See satellites
- Close to center
- Front (address)
- Linear



# Emergency Work

- Category A – Debris
  - Widespread
  - Centered
- Category B – Emergency
  - Coordinates not required
  - Widespread
  - No location
  - Centered
  - Linear









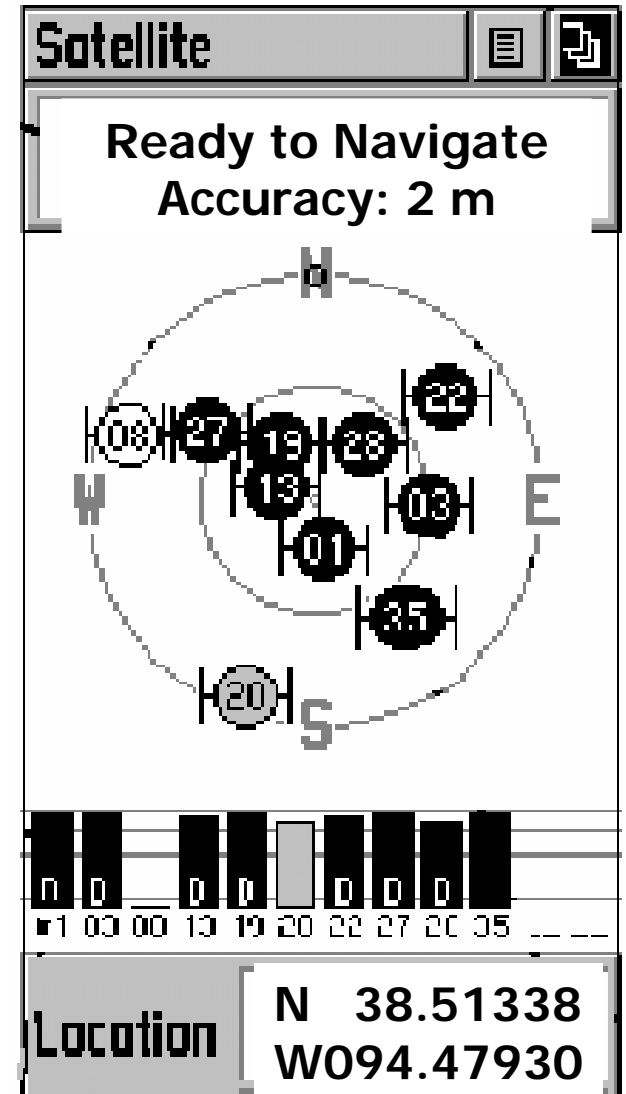


# Preliminary Damage Assessment



# Documentation

- Coordinates taken from GPS satellite page.
- Check format
  - hddd.ddddd 38.51338
- Write down as appear on unit (include N & W)
- **TAKE TIME TO WRITE CLEARLY**





# GPS to Field Notes Errors

- Writing down wrong coordinates
- Check coordinates after recording
- One person read coordinates, second person verify
- Write neatly
- Clearly record site

# Field Notes to PW

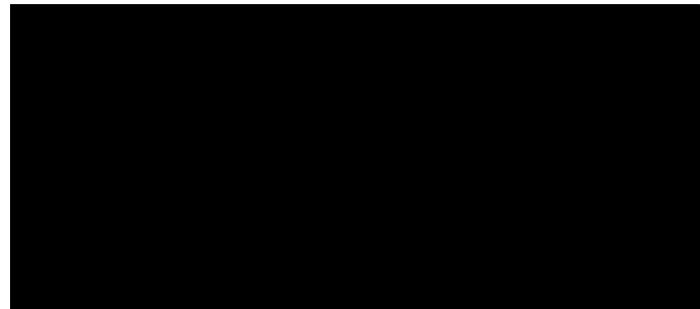
- Be Careful
- Check data entry
- N latitude entered as positive number
- W longitude entered as a negative number
  - All CONUS W (-)
  - Locations west of international dateline entered as E (+)



# Field Notes to PW

- Some digits easily confused
- 9 and 4
- 1 and 7
- 0 and 6
- 2 and 7

1169



# Coordinates for Single Site

FEDERAL EMERGENCY MANAGEMENT AGENCY <b>PROJECT WORKSHEET</b>				O.M.B. No. 3067-0151 Expires April 30, 2001	
<b>PAPERWORK BURDEN DISCLOSURE NOTICE</b> Public reporting burden for this form is estimated to average 30 minutes. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number is displayed in the upper right corner of the forms. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing the burden Information Collection Management, Federal Emergency Management Agency, 500 C Street, SW, Washington, DC 20472, Paperwork Reduction Project (3067-0151). <b>NOTE:</b> Do not send your completed form to this address.					
DECLARATION NO: <b>FEMA-                -DR-</b>		PROJECT NO.	FIPS NO.	DATE	CATEGORY
DAMAGE FACILITY				WORK COMPLETE AS OF: : %	
APPLICANT			COUNTY		
LOCATION				LATITUDE	LONGITUDE

If linear feature, second coordinates entered into comments

# Coordinates for Multiple Sites

**PROJECT WORKSHEET - PW #66 VERSION 0 - DR6127 - EDIT**

Project Descr. | Damage Facility | Cost Estimate | Special Considerations | Insurance | Env. Review | Mitigation | Assignments | Gen. Comments | Reviews

**SITE #8 OF 8**

**FACILITY NAME:** CONNER'S ROAD

**ADDRESS:** HIGHWAY #15, AT CONNER'S ROAD

**CITY:** PRESTON **STATE:** NH **ZIP:** 00000

**SITE LATITUDE:** 62.885467000

**SITE LONGITUDE:** -149.095545000

**LOCATION**  
AT THE INTERSECTION OF HIGHWAY 15 AT CONNER'S ROAD, SOUTH WEST CORNER

**DAMAGE DESCRIPTION AND DIMENSIONS**  
CLUVERT WASHOUT

**SCOPE OF WORK**  
REPLACE 18" CULVERT, CLEAN AND SHAPE SHOULDERS.

**Doubleclick to edit text**

**Add** **Delete**

Click on the ADD Button to add a new site to the PW, then store the Lat / Long for the new site

Display the Site to Delete, then select Delete to remove it from the PW Record

Latitude / Longitude Settings for a particular site

Scroll Bar will show the user if more than one site is stored on the PW and will allow easy access to each site by using it

PW will store several sites if desired

# Data Entry into NEMIS

- If electronic copy of PW available, copy and paste coordinates into NEMIS
- Often need to add (-) sign to longitude if in CONUS
- Check for correct format hdd.ddddd, make sure not in hdd mm.mmmmm
- Use job aid to verify coordinate in correct state.
- Typed versions of PW significantly reduces error.

# **Section Five**

## **Practical Exercise**



# Practical Exercise Review

# **Section Six**

## **Quality Control**

# Quality Control

- Are your coordinates correct?
- Several different methods to check.
- Compare to original field notes
- Check against acceptable ranges Job Aid
- Enter coordinates into mapping program
- Users (Data entry, GIS, Mitigation, Environmental, Historic) bring quality problems to PO or PAC

# Web-based Mapping Services

- Topozone
  - City name & coordinates
  - [www.topozone.com](http://www.topozone.com)
- US Census Tiger Map
  - City name & coordinates
  - [Tiger.census.gov](http://tiger.census.gov)
- MapQuest
  - Address only
  - [www.mapquest.com](http://www.mapquest.com)

TopoZone - The Web's Topographic Map, and more! - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Media Print View Source

Address <http://www.topozone.com/viewmaps.asp>

## topozone

VIEW MAPS GET DATA MY TOPOZONE WEB SERVICES ABOUT US HELP!

Place Name

Street Address

PLSS

UTM Coords

Decimal Degrees

Deg/Min (GPS)

Deg/Min/Sec

Place Name Search

Place Name  State  County

Type  Exact match ☒ Begins with this word or phrase ☐

Search

Street Address Search

Address searches are available to TopoZone Pro subscribers. If you are a TopoZone Pro subscriber, please click on **My TopoZone** to log in, then return to this page. For more information, see the [TopoZone Pro Information Page](#).

U.S. Census Bureau 10 Years on the Web

This mapping engine uses 1998 TIGER/Line® data and 1990 Decennial Census data.

Click ON THE IMAGE to:

- Zoom in, factor:
- Zoom out, factor:
- Move to new center
- Place Marker (select symbol below)
- Download GIF image

OR

REDRAW MAP

with any option selected below

OFF/ON Layers

- ☐ City labels
- ☐ Grid (lat/lon)
- ☐ Cens bg points

OFF/ON Layers

- ☐ Interstate labels
- ☐ St Hwy labels
- ☐ State Bounds

# topozone

**VIEW MAPS****GET DATA****MY TOPOZONE****WEB SERVICES****ABOUT US****HELP!**

Place Name

**Place Name Search**Place Name  State  County Type  Exact match ☒ Begins with this word or phrase ☐

UTM Coords

**Decimal Degrees****Street Address Search**

Address searches are available to TopoZone Pro subscribers. If you are a TopoZone Pro subscriber, please click on **My TopoZone** to log in, then return to this page. For more information, see the [TopoZone Pro Information Page](#).

**Public Land Survey System Search**

PLSS (Township/Range/Section) searches are available to TopoZone Pro subscribers. If you are a TopoZone Pro subscriber, please click on **My TopoZone** to log in, then return to this page. For more information, see the [TopoZone Pro Information Page](#).

**Universal Transverse Mercator (UTM) Coordinates**UTM Zone  Easting  Northing Coordinate datum ☐ NAD27 ☒ WGS84/NAD83

UTM Zone  Easting  Northing Coordinate datum ☐ NAD27 ☒ WGS84/NAD83**Latitude/Longitude - Decimal Degrees**Latitude  Longitude Coordinate datum ☐ NAD27 ☒ WGS84/NAD83**Latitude/Longitude - Degrees and Decimal Minutes**Latitude - degrees  minutes (with decimal)Longitude - degrees  minutes (with decimal)Coordinate datum ☐ NAD27 ☒ WGS84/NAD83**Latitude/Longitude - Degrees/Minutes/Seconds**Latitude - degrees  minutes  seconds Longitude - degrees  minutes  seconds Coordinate datum ☐ NAD27 ☒ WGS84/NAD83

# topozone

VIEW MAPS

GET DATA

MY TOPOZONE

WEB SERVICES

ABOUT US

HELP!

Map/Photo Info

Topo Download

Photo Download

USGS Topo Maps

☒ 1:24K/25K Series

☐ 1:100K Series

☐ 1:250K Series

Map Size

☒ Small

☐ Medium

☐ Large

View Scale

1 : 50,000

Update Map

Coordinate Format

DD.DDD

Coordinate Datum

WGS84/NAD83

☒ Show target

[Email this map](#)

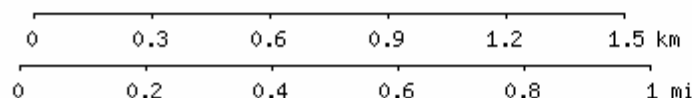
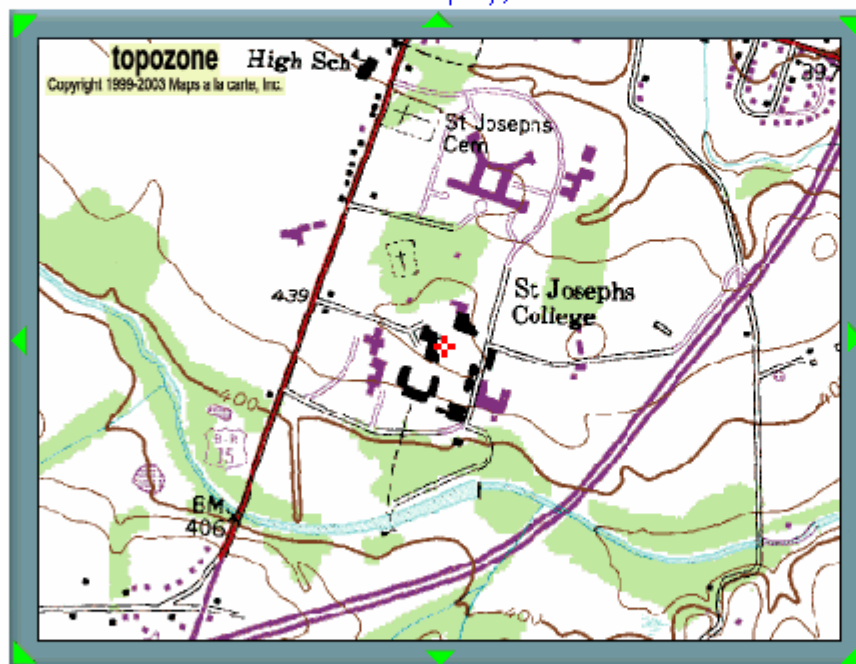
[Bookmark this map](#)

[Print this map](#)

39.6952°N, 77.3267°W (WGS84/NAD83)

USGS Emmitsburg Quad

[View TopoZone Pro aerial photos, shaded relief, street maps, interactive coordinate display, and elevation data](#)



M=-10.855

G=-1.487


[What's This?](#)

Click on the legend to download it as a GIF file.

**Place a marker on this map:**

Latitude(deg):

Longitude(deg):

Symbol:  

Label:

Marker URL:

*sorry, but no font control yet*

**Enter precise coordinates:**

Latitude(deg):

Longitude(deg):

Map Width(deg):

Map Height(deg):

**Choose a color palette:**



REDRAW MAP

**• You can also search for a U.S. city or town:**

Name:  State(optional):

or for a Zip Code:

**• Or choose from the following preset values:**

[Washington, D.C.](#) (default), [The Mall](#), [Continental United States](#), [Entire United States](#), [Northeast U.S.](#), [New York City](#).

This request serviced by (tiger.census.gov)

For further information, refer to the **TIGER Map Service** web page, located at URL:

<http://www.census.gov/ftp/pub/geo/www/tiger/tigermapping.html>





This mapping engine uses 1998 TIGER/Line® data and 1990 Decennial Census data.



Click ON THE IMAGE to:

- ☐ Zoom in, factor:
- ☐ Zoom out, factor:
- ☒ Move to new center
- ☐ Place Marker (select symbol below)
- ☐ Download GIF image

OR

REDRAW MAP

with any option selected below

OFF/ON Layers

- |                          |                          |                |
|--------------------------|--------------------------|----------------|
| <input type="checkbox"/> | <input type="checkbox"/> | City labels    |
| <input type="checkbox"/> | <input type="checkbox"/> | Grid (lat/lon) |
| <input type="checkbox"/> | <input type="checkbox"/> | Cens bg points |
| <input type="checkbox"/> | <input type="checkbox"/> | Cens bg bounds |
| <input type="checkbox"/> | <input type="checkbox"/> | Congress dist  |
| <input type="checkbox"/> | <input type="checkbox"/> | Counties       |
| <input type="checkbox"/> | <input type="checkbox"/> | Indian Resv    |
| <input type="checkbox"/> | <input type="checkbox"/> | Highways       |

OFF/ON Layers

- |                          |                          |                   |
|--------------------------|--------------------------|-------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | Interstate labels |
| <input type="checkbox"/> | <input type="checkbox"/> | St Hwy labels     |
| <input type="checkbox"/> | <input type="checkbox"/> | State Bounds      |
| <input type="checkbox"/> | <input type="checkbox"/> | Street Names      |
| <input type="checkbox"/> | <input type="checkbox"/> | US Hwy labels     |
| <input type="checkbox"/> | <input type="checkbox"/> | Water bodies      |
| <input type="checkbox"/> | <input type="checkbox"/> | Zipcode points    |

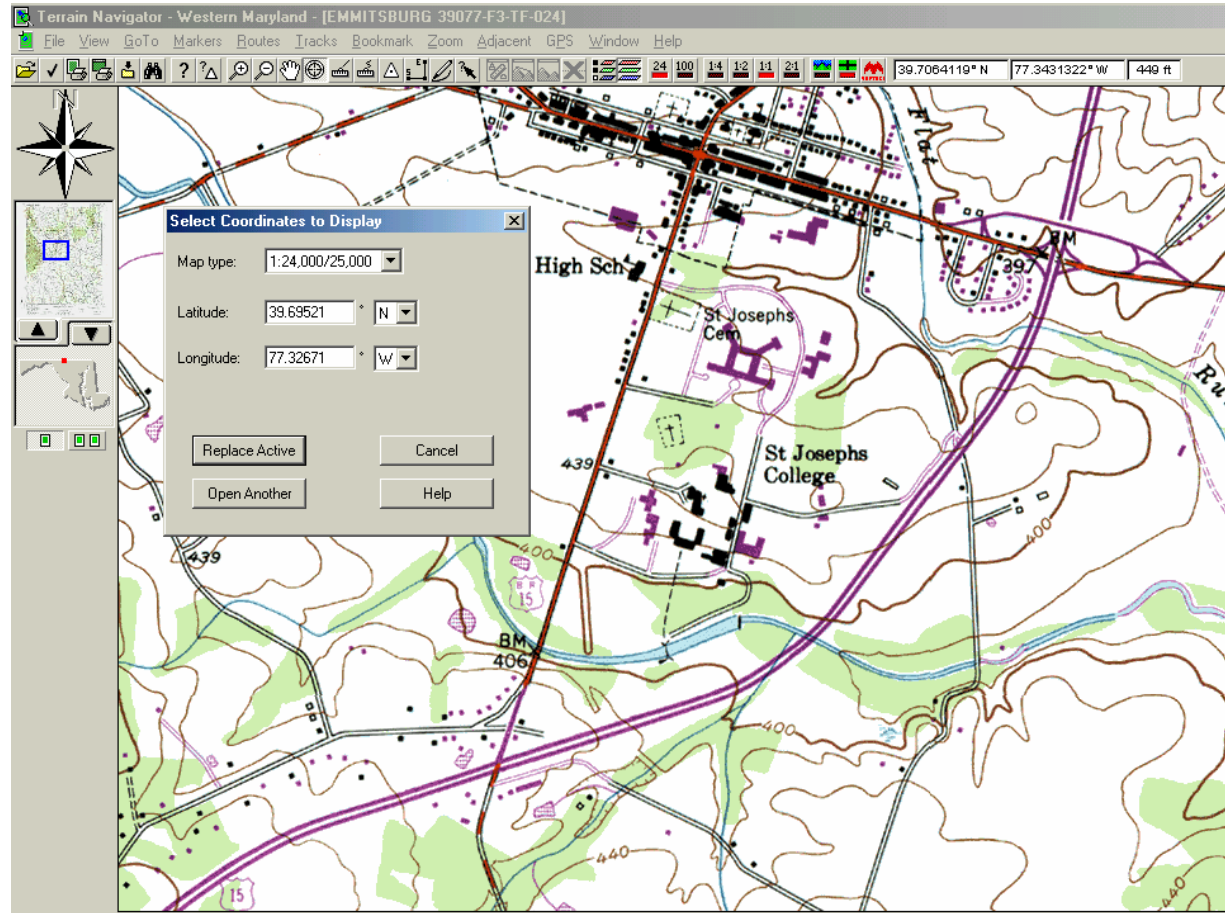


New  
Location



# Basic Mapping Programs

- Microsoft Streets & Trips
- Maptech Terrain Navigator



End and Overview



Populated Places

Boundaries

Transportation

Miscellaneous

Find a Location America Countries-

0 mi



**Find** ? X

Address | Place / Data | **Lat/Long**

Type the latitude and longitude as decimal values or in degrees, minutes, and seconds in the boxes below.

Example: The map is currently centered on Latitude 40.2523, Longitude -97.3518

Latitude (north is positive):

Find

Longitude (east is positive):

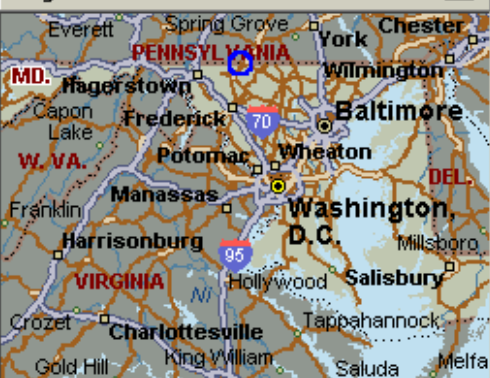
OK Cancel







## Legend and Overview



## Pushpins

My Pushpins

## Populated Places

## Boundaries

## Transportation

## Parks and Reserves

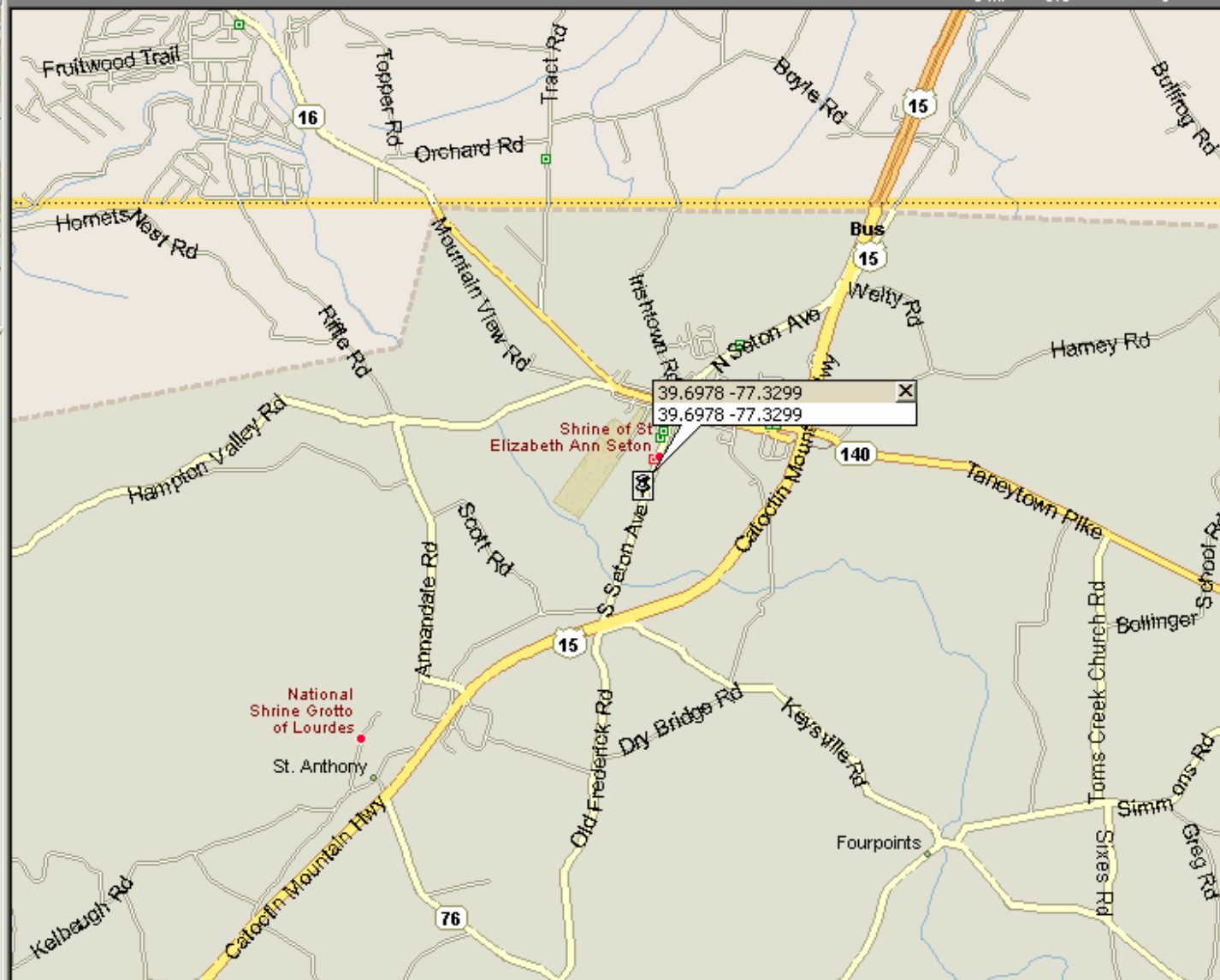
## Points of Interest

## National Park Facilities

## Miscellaneous

North America United States Maryland Emmitsburg

0 mi 0.5 1



**Find** ? X

Address Place / Data Lat/Long

Country:  
United States

Type as much of the address as you can.

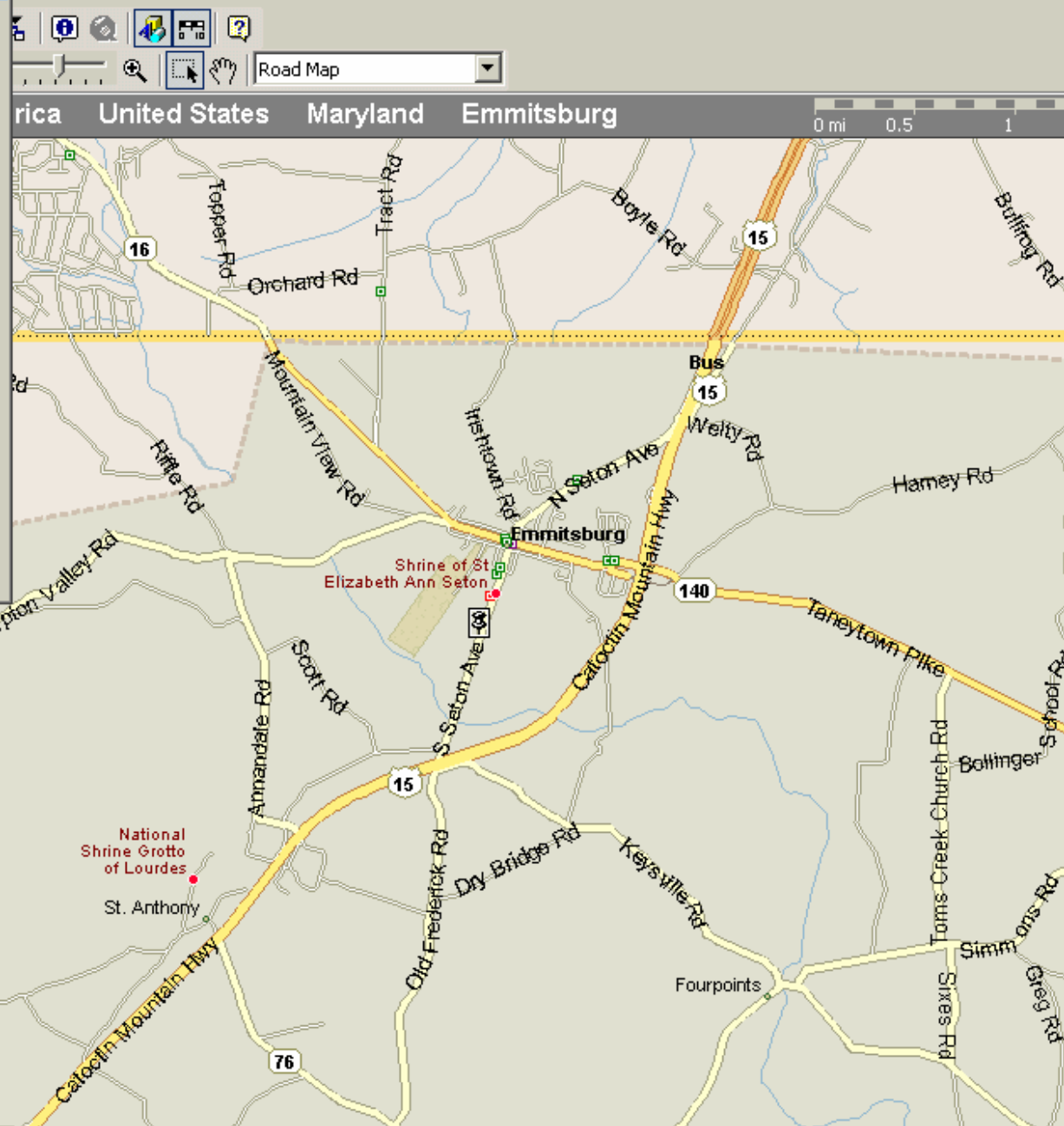
Street address:  
16836 S. Seton Ave Find

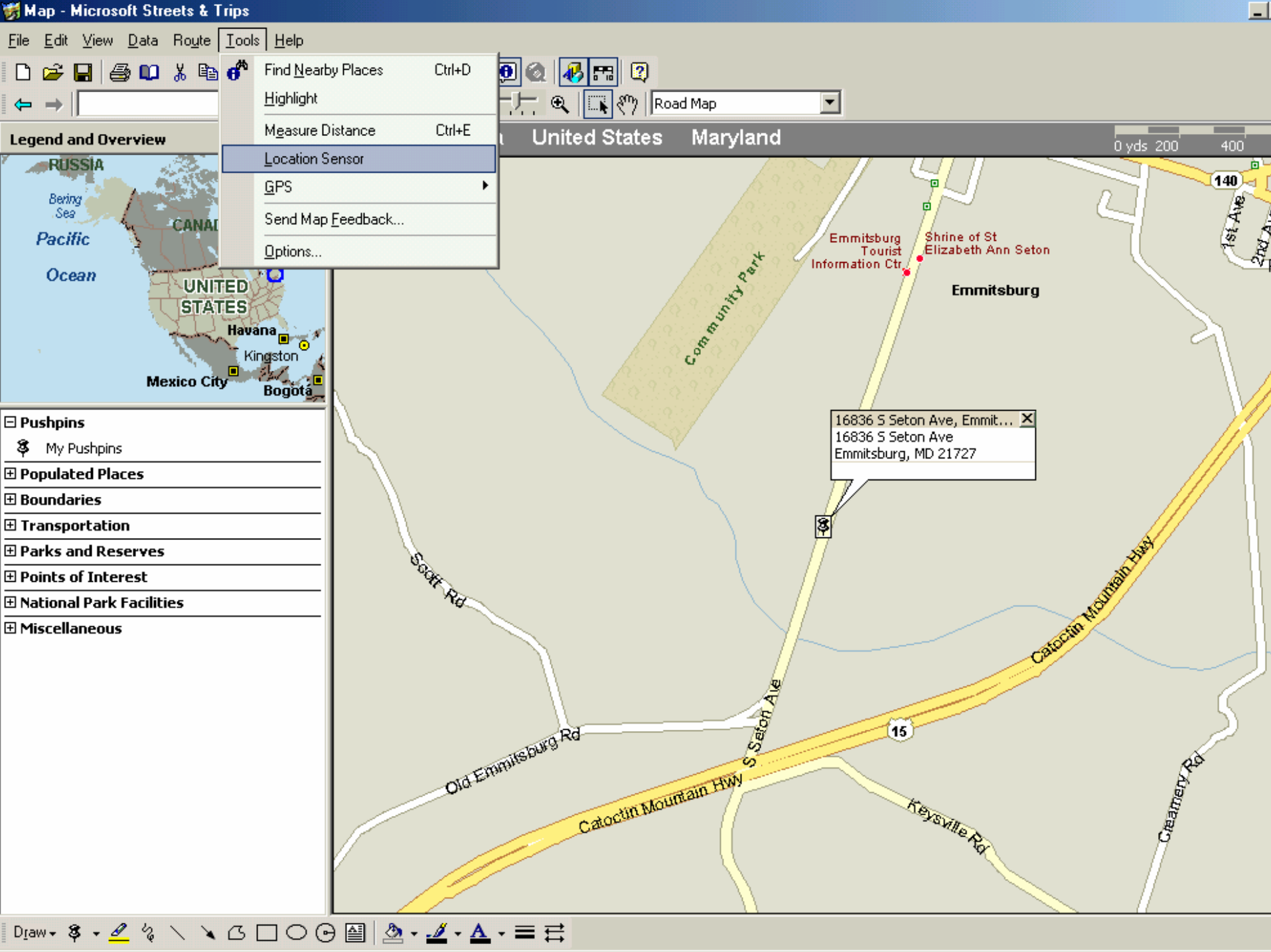
City:  
emmitsburg

State: ZIP Code:  
MD-Maryland

OK Cancel

- Transportation
- Parks and Reserves
- Points of Interest
- National Park Facilities
- Miscellaneous







Find

Road Map

## Legend and Overview



## Pushpins

My Pushpins

## Populated Places

## Boundaries

## Transportation

## Parks and Reserves

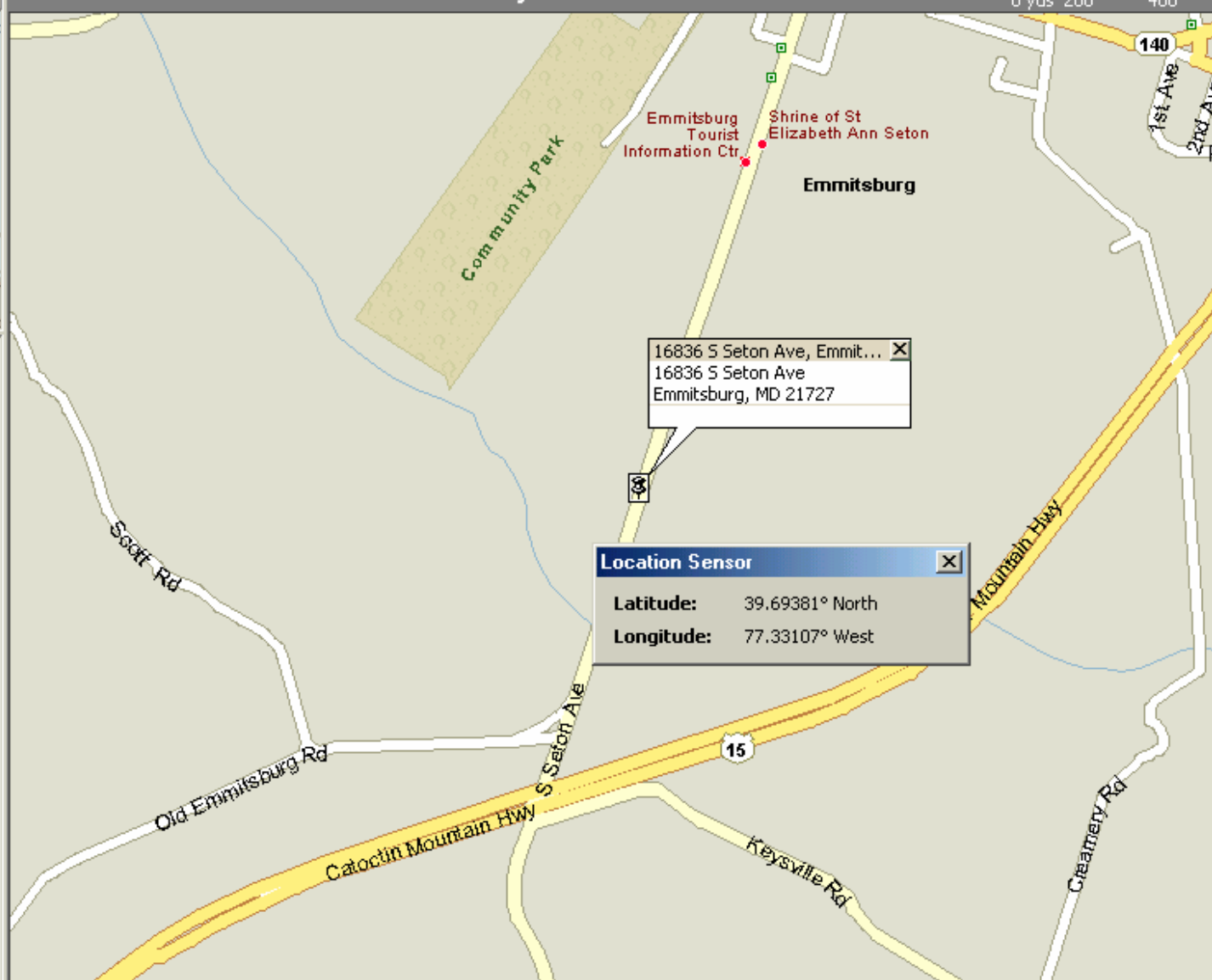
## Points of Interest

## National Park Facilities

## Miscellaneous

North America United States Maryland

0 yds 200 400



16836 S Seton Ave, Emmi...  
16836 S Seton Ave  
Emmitsburg, MD 21727

## Location Sensor

Latitude: 39.69381° North

Longitude: 77.33107° West



# **Section Seven**

## **Summary**

# Objectives

- ✓ Explain FEMA's use of coordinates.
- ✓ Explain basic GPS theory as applied to actual field use.
- ✓ List common problems and their prevention.
- ✓ Demonstrate the ability to configure the unit, obtain, record, and verify coordinates in the field.

# Summary Source of Error

Type of Error	Source of Error	Effect
dGPS	GPS system	3 m
GPS	GPS system	15 m
Wrong Datum	Configuration	0.1 km
Wrong Format	Configuration	50 km
Transposing Digits	Human	5,000 km
Wrong Sign	Human	Half the world

# Summary Field Operation

- Good safe location
- Turn on unit
- Wait for good satellite signal
- Walk to proper location
- Record coordinates
- Quality check data upon return

# Additional Resources

- User's manual – [www.garmin.com/](http://www.garmin.com/)
- Tutorial on GPS
  - Trimble site [www.trimble.com](http://www.trimble.com)
  - Garmin book [www.garmin.com](http://www.garmin.com)
- WAAS Information FAA site [gps.faa.gov](http://gps.faa.gov)
- USGS Mapping and Datums [www.usgs.gov](http://www.usgs.gov)
- USCG GPS Site [www.navcen.uscg.gov](http://www.navcen.uscg.gov)

# Questions?